VOLUME III

TECHNIC

JOHN S COULTER

PRINCIPLES AND PRACTICE
OF
PHYSICAL THERAPY

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VOLUME III

CHAPTER ONE

EXERCISES FOR THE DEVELOPMENT OF GOOD BODY MECHANICS

HARRIET COLE AND LLOYD T BROWN M D

FOREWORD

This book, Volume III is planned to make possible the practical application of the principles so carefully explained in the previous volumes. The aim of physical therapy is to bring the body or its special parts to a condition as nearly normal as possible. It is, therefore of the utmost importance that any one practicing the art of physical therapy should know not only the muscles joints and ligaments and their actions but that he should know also the principles of *body mechanics* The definition of *body mechanics* (Brown Vol I) can well be repeated at this point

"Body mechanics is the mechanical correlation of the various systems of the body with special reference to the skeletal muscular visceral and neurologic systems Normal body mechanics obtains when this mechanical correlation is most favorable to the function of these systems

The relationship of body mechanics to nearly all conditions in which physical therapy is used is so intimate that if the fundamental principles of body mechanics are not known and are not applied the physical therapist is missing a great opportunity not only to benefit the patient but also to make his work more interesting to himself as well as to the patient.

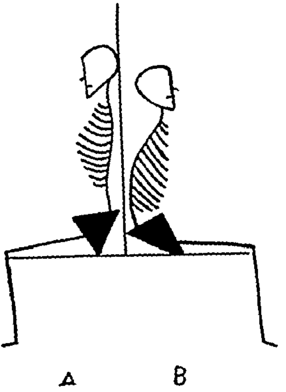
It is because the relationship of correct body mechanics to nearly every condition in which physical therapy can be properly applied is so important that this chapter is placed first in the volume on Technic. Reference to Brown (Vol. I) "Anatomic Structure and Body Mechanics " is suggested at this point.

IMPORTANCE OF GOOD POSTURE

The aim of postural exercises is to secure the poise of the body in the proper balanced line without muscle tension or rigidity A well poised body means better health through improved organic function better work, both physical and mental and greater strength and

Fig. 1.—Correct lying position. Chin in chest up normal cervical, dorsal and lumbar curves of the spine with the normal angles of the ribs and pelvis.

Fig. 2.—Incorrect lying position. Chin out, chest down with increased cervical dorsal and lumbar curves of the spine. Pelvis tipped forward.



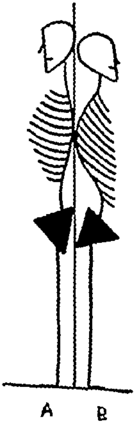


Fig. 3.—A Correct sitting position Chin in ribs up back flat pelvis nearly horizontal. B Incorrect sitting position. Chin out ribs down, increased cervical, dorsal and lumbar curves Pelvis tipped backward.

Fig. 4.—A Correct standing position Head up chin in, ribs up, pelvis nearly horizontal, back nearly flat B Incorrect standing position Chin out, ribs down, increased cervical, dorsal and lumbar curves

endurance through a lessening of skeletal muscle tension and its resultant fatigue

Good body mechanics means the use of the body as a whole in proper poise The ability to use the body rightly should be taught in the lying (Figs. 1 and 2) sitting (Fig. 3) and standing (Fig 4) positions as well as in the change from one fundamental position to another such as rising from a chair or stooping to pick up a heavy

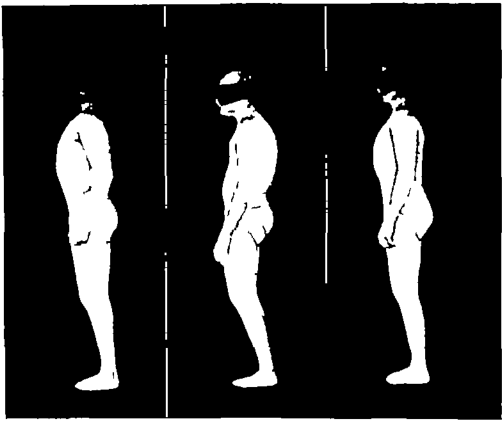


Fig 5—Poor body mechanics. Over corrected standing position

Fig 6—Poor body mechanics. Incorrect standing position.

Fig. 7—Good body mechanics. Correct standing position.

object. The teaching of proper body mechanics does not imply or try to include the development of great muscular strength in any one muscle group it concentrates on the ability to use the muscles which are present letting the normal use in daily life develop muscular strength according to its needs

The commonly exaggerated standing position with the shoulders back, and chest high and the accompanying hollow back and pronated feet is not one of good poise (Fig 5) The maintenance of such a position requires continued and abnormal muscle effort and so causes

fatigue. This position is as incorrect as the extreme slumped position which is marked by a prominent abdomen round shoulders hollow chest, and a forward inclination of the head and neck (Fig. 6) In either of these positions the body is out of balance and muscle and nerve energy is wasted. The degree of faulty position in either case varies according to age and occupation of the individual, but it always indicates unnecessary fatigue which, sooner or later will cause untoward results.

That the body may be used properly the trunk alignment should be correct. This means that the weight must be well forward and on the outer borders of the feet, the lower abdomen pulled in and up, the back flat, the head up and the chin in The body should be stretched tall without being rigid the shoulders and chest will then fall into their own balance line (Fig 7)

The old method of telling a child to throw out his chest and pull his shoulders back was faulty in that it disregarded the keynote of practically all posture correction—the ability to use the lower abdominal muscles When a child is told to lift his chest and pull his shoulders back, he almost invariably assumes a position of extreme lordosis (Fig 5) He has thus diverged greatly from the correct weight-bearing lines and when he relaxes has every prospect of setting back to his original faulty posture He has not learned how to develop a firm flat lower abdomen which is the foundation of good posture Therefore, he should be taught a position which not only throws the weight well forward on the feet but also emphasizes the inward upward contraction of the lower abdominal muscles To accomplish the latter, the child should be taught to get the feeling of pulling the abdomen in so hard that it pushes the head up with the chin in. This pull should not interfere with normal breathing for the contraction should be only from the lower attachments of the abdominal muscle group The upper abdomen should be broad and the rib angle should be wide. If the chest is forcibly raised as mentioned above there is a consequent flattening of the abdominal wall which takes place without any actual effort on the part of the abdominal muscles and is therefore, of no value because when the chest relaxes the abdomen sags to its original position

In the upright position, as one becomes older the tendency is for the abdomen to relax and sag more and more allowing a ptotic condition of the abdominal and pelvic organs unless these lower supporting abdominal muscles are taught to contract properly As the abdomen relaxes there is a great tendency toward a drooped chest with a narrowed rib angle forward shoulders prominent shoulder blades a forward position of the head and probably pronated feet. When the human machine is out of balance physiologic function cannot be perfect muscles and ligaments are in an abnormal state of tension and strain. A well-poised body means a perfectly working

machine with the least amount of muscle effort and, therefore, better health and strength for the daily life

The value of the following lists of exercises lies not in the amount of motion or muscular work obtained but in the way in which they are done The actual amount of motion is not important, for that increases with the ability to use the muscles and the strength of the muscles comes with proper use The habit of proper use must be taught. Fifteen minutes of intelligent work twice a day is of more value than extended periods of hard-driving exercises

The development of the various trunk muscle groups is of the greatest importance and of real corrective worth. Exercises of the legs and arms are mainly of circulatory value unless they are particularly indicated for some corrective measure

The first exercises should be in a recumbent position preferably on a hard surface. This position is most favorable for good mechanical alignment, with all the muscles relaxed therefore the group to be worked with may be reached with the least amount of muscle effort and localized exercise may be most easily performed

Breathing exercises generally begin the list and may be worked in with others as the list progresses The two most essential points in the breathing exercises are the forward upward chest elevation, and the lateral spread of the mid or lower rib region True diaphragmatic breathing should always be used This means elevating the chest during inhalation holding the elevated chest position and exhaling by an inward upward pull of the upper abdominal muscles This may allow only a partial exhalation of the amount of air drawn into the lungs The same conditions hold true of the lower rib region here the expansion is lateral and the rib spread is held during exhalation The elevated and expanded chest allows for the complete excursion of the diaphragm

It will be noted that nothing has been said so far about the amount of chest expansion. From the point of view of correct diaphragmatic breathing the amount of chest expansion is not important A chest with a relatively small amount of expansion that is habitually held in a correct mechanical position will have in the ordinary respiration better diaphragmatic action than a chest with a large expansion which is habitually held in a poor mechanical position The drooped chest of faulty body mechanics brings the origin and insertion of the diaphragm muscle so close together that correct diaphragmatic action is difficult.

The most important muscles in the teaching of good body mechanics are the abdominal group The patient must be taught to use them properly—that is from the lower attachment upward. The control of these muscles and the ability to use them, whether lying sitting or standing are the foundation of this work.

A patient should be kept on a list of exercises to be done lying down until he has knowledge of the use of these muscles The aim of

the work is to teach a good habit for daily use, not hard muscle effort. The following exercises need no apparatus or machines They can be done on the table or the floor

Exercises to be Done While Lying Down

Exercise 1 (Fig 8) —Lie flat on the back with hands at back of neck or on top of head if the back is hollow in this position, bend the knees. Breath deeply, raising the chest, do not allow the

Fig. 8.—Normal cervical, dorsal and lumbar curves due to the position. Upper chest lift at inhalation.

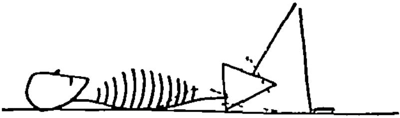


Fig. 9.—Lumbar curve flattened. Pelvis tipped back.

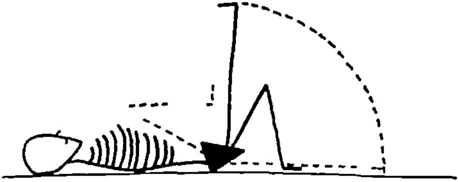


Fig. 10—Ribs lifted and made nearly flat by position. Arc of motion of leg, without change of body position.

back to lift Hold the chest up and exhale by drawing the abdomen in Take the next breath against the lifted chest exhale as before, with out allowing the chest to drop The amount of breath passing is not important the important points are the constantly lifted chest which is pushed higher with each breath, and the exhalation by the inward upward contraction of the upper abdomen

Exercise 2 (Fig 9)—Lie flat on back, hands at back of neck chin in knees bent. Contract the lower abdominal muscles with an inward upward pull tighten the buttock muscles and so flatten the whole back against the floor relax and repeat This is not a breathing exercise but the chest must be held up and the chin in The muscle effort is entirely in the pelvic region and low back

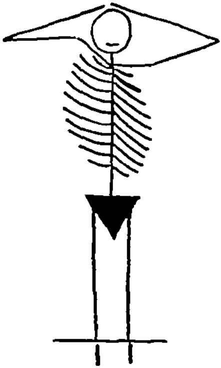


Fig 1—Chest and ribs lifted by lying position. Ribs of one side separated by a muscle pull.

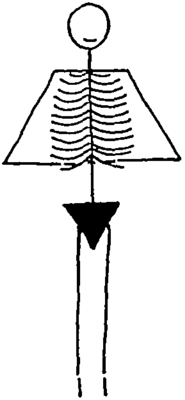


Fig. 1—Ribs and chest lifted by lying position. Lateral spread of lower ribs at inhalation.

Exercise 3 (Fig 10)—Same position with bent knees Bend one knee over the chest, straighten leg and lower slowly holding chest up chin in abdomen in keeping the back flat on the table. Repeat.

Exercise 4 (Fig 11)—Lie flat with hands clasped on top of head elbows back chin in back flat Stretch one whole side feel a lateral upward spread of the ribs hold the stretch and slightly contract the lateral abdominal muscle on the same side relax. Repeat alternate.

Exercise 5 (Fig 12)—Lie flat, chin in chest up back flat. Grasp ribs at costal margins firmly with both hands breathe deeply

pulling ribs outwards, hold ribs out and exhale by drawing upper abdomen in Hold the lateral spread of the ribs and inhale again spreading the ribs farther Do not relax until the required number of breaths have been taken. The amount of air passing is not important, the lateral spread of the ribs and the increased motion of the diaphragm are the points worked for

Arm, Neck, and Shoulder Exercises

Arm, neck, and shoulder exercises in this same lying position are of more value than those done while standing because the body is in good position without muscular effort and localized exercises may be used to more advantage In all of the following exercises the most important feature is whether the body, chest, abdomen spine, and head are held in a correct position This is of much more consequence than the actual movement of the extremities.

Exercise 1 —Lie flat, chin in, knees bent if the back hollows elbows bent and held against the ribs Extend arms out to the side at shoulder level, palms turned back return and repeat.

Exercise 2.—Same position, extend arms behind head keeping elbows on body level, palms facing with arms at full extension return and repeat.

Exercise 3 —Same position chin in Hold arms extended sideways at shoulder level rotate shoulders and arms backward. Let the shoulders carry the arms in order to allow the rhomboids to contract.

Exercise 4.—Same position hands at back of neck. Pull chin in, stretching back of neck relax repeat. Do not lift the head or shoulders off the table.

Exercise 5.—Same position. Hold chin in, turn head to side alternate.

Exercise 6 —Same position. Hold chin in bend head to side toward the shoulder alternate.

Exercise 7 —Same position arms straight at side. Raise arms sideways to back of head keeping them on body level stretch whole body upward Keep chin in and back flat.

Sitting Exercises

A list of sitting exercises may be taken up when the lying exercises have been mastered. The sitting position is preferable to the standing

position as the next step in the progression of exercises The reason is that in the sitting position it is easier to keep the back flat and the abdomen in. The first lateral flexion and rotation should be done in this position because the pelvis and hip joints are locked and the motion is localized in the upper spine.

Exercise 1 —Sit straight and tall abdomen in, back flat head up and chin in hands on hips Breathe deeply pushing chest up and forward hold chest up and exhale by drawing abdomen in and up relax and repeat.

Exercise 2 —Same position hands clasped on top of head elbows back chin in head up chest up and forward. Pull lower abdomen in and up relax, repeat. Do not hunch shoulders

Exercise 3 —Same position Stretch one whole side spreading ribs apart, pull abdomen in alternate Do not sway or bend the trunk but simply stretch the whole side.

Exercise 4 —Same position hands on hips Bend upper part of trunk to side alternate.

Exercise 5 —Same position Turn upper part of trunk to side alternate.

Exercise 6 —Same position Tighten buttock muscles relax repeat. Hold rest of body in good line

Exercise 7 —Same position hands clasped on top of head, elbows back, head up chin in back flat Breathe deeply pulling chest up hold chest up and exhale by drawing abdomen in

Requirements of Good Standing Position

The progression of exercises is usually from lying to sitting to standing work. The progression is made from one to the other as soon as the patient has mastered the fundamentals of good body mechanics The object of the whole series is a well-poised body with the least amount of muscular effort If the poise becomes rigid or strained the aim of the exercises has been missed The effort should be to teach the use of the whole body in good anatomic and mechanical alignment which means the least amount of muscle work and therefore the least amount of strain and fatigue.

A good standing position consists of the following feet comfortable straight ahead with the weight well forward and on the outside borders abdomen in back flat chest up and forward head up

chin in, and body relaxed. To relax does not mean to collapse, but to balance the weight of the body on the feet like a stick balanced on a finger With the body in good line, find the balance point and live with it. When such a position has been acquired exercises of any type or theory or "ism' may be done with the greatest amount of benefit as long as they do not force the body into positions of deformity or bad body mechanics.

STANDING EXERCISES

Exercise 1 —Stand against wall feet four to six inches away from wall head hips and shoulders against wall, chin in, stretch tall,

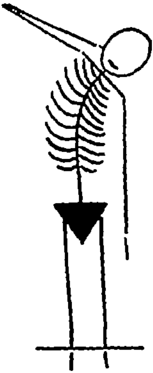


FIG. 13 —Lateral flexion of dorsal spine Hips and pelvis fixed. Elbow and head back, chin in.

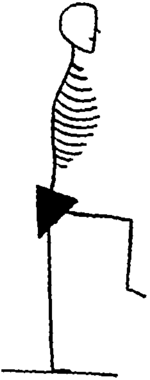


FIG. 14 —Flexion of the knee and hip Ribs, chest and head up, back flat.

hands at back of neck. Push elbows back breathe deeply hold chest up exhale by drawing abdomen in Do not let the back arch away from the wall

Exercise 2 —Same position hands on hips. Pull lower abdomen in and up tighten and pull buttocks down to flatten the back against wall relax repeat Keep chest up and chin in do not bend the knees

Exercise 3 —Same position hold abdomen in and chest up Pull chin in, stretching back of neck relax repeat Do not lift shoulders or let head leave wall

Exercise 4.—Good standing position feet straight, weight well for ward and on outer borders head up chin in chest forward abdomen in back flat (Fig. 13) One hand at back of neck, elbow back, other hand on thigh Bend upper part of trunk to side of lower hand straighten and repeat. Do not let hips sway

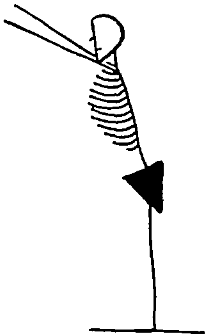


FIG. 15—Forward upward lift of arms, chest and ribs. B ck flat and head up, weight f rward.

Exercise 5 —Good standing position feet apart arms held side ways at shoulder level palms down head up chin in chest forward abdomen in back flat. Bend upper part of trunk to side alternate Do not sway at hips or ankle joints

Exercise 6 —Same position Turn upper part of trunk to side alternate.

Exercise 7 —Good standing position hands on hips weight well forward, head up chin in Stretch tall Walk on straight line make forward heel meet backward toe toe in slightly

Exercise 8 —Good standing position, hands on hips stretch tall, head up, chin in chest forward abdomen in, back flat (Fig. 14) Bend knees up alternate. Do not allow upper part of trunk to sway

Exercise 9 —Good standing position Inhale, raising arms forward and upward rise on toes stretch tall (Fig 15) Let arms sink to sides as heels sink, exhale by drawing abdomen in Keep chest up and forward and back flat.

Foot Exercises

Exercises to correct faulty body mechanics should always include training in the proper use of the feet It should be remembered that when a muscle is used in the right way it becomes stronger and therefore, before any foot exercises are given the patient should be shown how to use the feet properly The correct standing position must begin with the weight bearing and position of the feet. The feet should be comfortably straight ahead with the weight on the outer borders toes on the ground. Use of the feet in this position means correct use of all the foot muscles.

Exercise 1 —Sitting cross knees Make half circle with foot down, in and up The inward, upward pull is the important result.

Exercise 2.—Same position turn foot in slightly Pull foot up and push down, using ankle joint.

Exercise 3 —Same position. Turn foot in, curl toes under hard Pull foot up when toes are curled

Exercise 4.—Stand weight well forward, body in good line hands on hips Lift inner borders of feet, relax halfway, and repeat Toes cling to floor

Exercise 5.—Same position Lift inner borders of feet, rock from heel to toe. Do not let inner borders of feet down

Exercise 6 —Heel and toe walk on line Described in previous list

Exercise 7 —Sitting pick up marbles with toes turn foot up and hand to yourself

Exercise 8.—Sitting place bath towel folded full length, on floor using toes and outer border of foot, draw whole length of the towel towards you Do not let heel move out of position or rest on towel.

CHAPTER TWO

USE OF HEAT AND COLD

FRANK H EWERHARDT M D

INTRODUCTION

The use of heat and cold as remedial agents are as is well known as old as medical history itself Though the uses are still largely of empirical value it can be stated that in recent years considerable clinical and laboratory work has been done to rationalize at least partly the therapeutic application of this ancient form of treatment. Details of modern methods and apparatus for the application of heat to the body will be discussed in the chapters on Hydrotherapy Medical Diathermy Fever Therapy and Light Therapy Here it is appropriate only to outline a few of the general principles and to indicate the range of the procedure

SOURCES OF HEAT AND COLD

Transmission of heat may be accomplished by conduction convection radiation and conversion Conduction is the passing of heat from one body to another by the medium of contact Convection is the transfer of heat by the motion of circulating air Radiation is the transfer of heat rays through space in a straight line as by the sun s rays Conversion is the changing of one form of energy to heat by virtue of tissue resistance an example of which is the alternating high frequency current commonly called diathermy Superficial heat is imposed by means of apparatus based on the principles of conduction and convection. Conductive types of equipment are the hot water bag the electric pad the hot metal flask the chemical bag and hot baths The convective means of applying superficial heat are the hot air blower and the air-conditioned fever cabinet. In heating by radiation short or near penetrative infra red rays are produced by the sun carbon arc gas-filled tungsten lamp and carbon filament incandescent lamp The far or long infra red rays are produced by infra red radiant heaters Conversive or deep-seated heat is the result of the passage of a very high frequency alternating current called diathermy

Depth of penetration of radiation is closely related to wavelength intensity and the kind of soft tissue involved Coblentz [184] discusses this matter succinctly in the A M A. 'Handbook of Physical Ther

apy," Third Edition He states, "Depth of penetration is a relative term, whether we mean penetration to a depth where the intensity is reduced to 1/10 or 1/10,000 of the incident radiation, and this in turn depends upon the threshold of the biologic effect sought, whether of photochemical action temperature sensation, etc.'

"The part of the spectrum to which the skin is relatively transparent (but in which there appears to be no specific biologic action other than nerve stimulation) extends from about 5,000 angstroms to 12 000 angstroms with a wide maximum of transparency in the region of 7,000 to 9,000 angstroms "

Recent transmission measurements seem to indicate that the depth of penetration is not so great as formerly supposed. Furthermore, with increase in knowledge of radiation therapy, less emphasis is being placed upon this question."

It should be stated that, so far as is known, infra red radiation is entirely thermal in character though differing somewhat in the reaction of sensation to the patient. In a clinical investigation, using a variety of infra red units we learned that patients who were subjected to radiations which were especially intense in the long wave field, for example, the common bathroom heater were wont to complain, suggesting that these long nonpenetrating wavelengths were excessively stimulating This was but confirming what has been reported by others (Oppel and Hardy [30], Laurens and Foster [33a])

Water —Water has always been the common medium to transmit heat to the human body because of its physical characteristics Usable as a solid, a gas or a liquid easily obtainable cheap its most striking property however is the power of absorbing and consequently conveying large masses of heat. Since the specific heat of the human body is nine tenths that of water it is possible to alter body temperature, locally and systemically by the addition or subtraction of heat and cause reactions which, if properly used, produce desirable therapeutic effects.

Hot Air —Hot air may be applied locally by the various types of "bakes' in which the part is exposed to dry air at a temperature varying from 49 to 148 C (120.2 to 298.4 F) At these high air temperatures great care must be exercised to see that the part to be treated does not touch any substance that is more readily heated and more conductive than itself otherwise serious tissue burns may be sustained Hot air may be applied to the entire body surface in the form of the Turkish bath. In this the patient is conducted through a series of heated apartments the first having a temperature of 38 C (100.4 F) and the last 66 C (150.8 F) or above. After perspiration has been freely established the patient is thoroughly washed and rubbed and then optionally given a cold douche or a plunge bath.

Vapor.—A mixture of steam and air may be used locally or generally in much the same manner as air, i.e. for general application, as the old fashioned Russian bath and the steam cabinet bath. A cabinet bath is given with the patient sitting on a Turkish towel-covered wooden stool with feet on a towel-covered wooden floor and head projecting through a hole at the top of the cabinet, the neck "washered" by a Turkish towel much as an electric cabinet unit, but using steam instead of light.

Pastes.—Semiliquids and semisolids (pastes) are easily heated or chilled and applied but are not so readily changed as stupes and compresses. Accordingly they serve better for hot applications as they tend to prevent tissue surface cooling. The application may be kept hot by placing a hot water bag over it. Among the pastes obtainable from the pharmacist are glycerin and kaolin, antiphlogistin, muds, etc.

Chemical Heating Pads.—The chemical heating pad similar to the hot water bottle uses a chemical composition which, with the addition of water produces heat.

Electric Heating Pads or Blankets.—This type essentially consists of a cloth pad incorporating wires which when brought to a proper heating point give rise to conductive heat. Such heat has little power of penetration. These pads may be had in a variety of sizes, a more recent one being a narrow band about three inches wide and long enough to surround a knee joint. The application of electric pads should be made only while the patient is awake as there is a definite risk of burns. Usually such pads have a central control grading from low, medium to high temperatures. It is important to note here that at all times electric pads must be watched. Short circuits are a possible cause of damage. Obviously the best quality of equipment is advisable because of safety.

Paraffin Bath.—A very efficient method of applying local heat is the use of hot paraffin. The patient dips hands or feet in and out of the bath quickly so that a thin coating of the melted substance congeals on the skin. This is repeated from six to eight times when a sufficient thickness will have been formed. One may allow the part to remain in the bath from ten to thirty minutes with comfort and thus enhance the effect of the heat. The paraffin is then removed much as one removes a glove. A knee, shoulder or back is treated by applying the hot paraffin directly with a clean paint brush.

Usually about eight pounds of commercial paraffin is used. This is placed in a double boiler and heated to the melting point. An extraordinarily high degree of temperature 130 to 135° F. (54.4 to 57.2° C.) is tolerated by the skin when paraffin is the medium used. At this

temperature water would be intolerable Lampert[22] and Zeiter[23] mention various theories which have been offered to explain this phenomenon that a layer of vapor prevents a too rapid transference of heat to the skin that the initial layer of paraffin acts protectively and that actually less heat comes in contact with the skin than is indicated by the temperature reading of the hot paraffin

Lampert believes the last theory to be sound on account of the physical character of heat capacity and consequently heat transference He states that paraffin has only one third the heat capacity of water, that less heat is transferred to the skin and that therefore the skin can tolerate an application of paraffin of a much higher degree than that of water the ratio being about 135 and 115 F (57.2 and 46 1 C)

Electric Cabinet Bath.—The electric light cabinet is found in most physical therapy departments. The unit usually contains between 40 and 50 mazda or carbon lights has mirrors or reflecting material on the inside and is so arranged that while the patient's body is subjected to the influence of the lights his head is outside of the cabinet. This offers very definite advantages over the old fashioned Turkish bath or steam room. These are some of the advantages It combines both radiant light and convective heat Light is used because of its penetrability of soft tissue thereby hastening the process of perspiration. This frequently can be induced in from five to ten minutes with a cabinet temperature of less than 105 F (40 6 C) The significance is that, compared with a hot air or steam bath the electric cabinet bath causes less strain on the heart The patient is more definitely under the control of the nurse a fact very important in advanced cardiorenal cases where elimination is desirable The pulse rate can readily be taken and the heart action controlled by cold applications to the head The blood can be further diverted from the head by means of a hot foot bath given at the same time.

Diathermy—Prolific literature on the clinical use of diathermy has developed and favorable results have been reported for a great variety of unrelated conditions Unfortunately many of these favorable reports are based on uncontrolled and exceedingly fallacious clinical evidence Its wide use has resulted partly from its appeal to the imagination of physicians and laymen as something quite extraordinary and partly from the hope that it might be helpful though not understood So far as we know the effects are due entirely to the heat developed, and such fanciful phrases as cellular massage" etc., are of no help to our understanding. Diathermy is a valuable method of applying heat but should not be regarded as a method which cures a disease but rather as a useful measure wherever heat is indicated

The theories of selective heating specific bacteriologic effect, and specific electric effects emanate for the most part from workers in

Europe It is hardly open minded to assume that these men are unsound in their conclusions but rather preferable to deduce that their findings are not as yet sufficiently supported by comparative and control evidence to warrant acceptance It is well to remind ourselves that medical research has so far made presumably only elementary discoveries in the application of the known radiant energies confined in the electromagnetic spectrum and that a vast area is as yet unexplored

It is proper to mention at this point that the employment of the short wave diathermy is not without danger because of the uncertainty of knowing just how much heat may be produced in the deep tissues at a given period since there is at hand at the present time no definite practical measuring device to give us this information accurately In the application of infra red or the conventional diathermy the skin tolerance of the patient was accepted as a safe guide in interpreting dosages This cannot very well be done with the use of the short wave because the skin temperature may be less than that of the deeper tissue. This statement will be better appreciated by the knowledge that in a customary treatment of the thigh a temperature of 108 F (42 2 C) and more may be obtained at a point near the femur while the skin temperature may be only 104 F (40 C) For a more thorough study of diathermy the reader is referred to a fuller treatment of that subject in this volume.

Hydriatic Measures.—Baths may be conveniently arranged into three groups—very hot hot, warm neutral, tepid cool and cold For specific therapeutic purposes the temperature scale may be divided as follows

	Degrees F
Very hot	Above 105
Hot	102–105
Warm	98–102
Neutral	92– 98
Tepid	80– 82
Cool	80– 65
Cold	65 and lower

In prescribing baths the technician must necessarily adhere closely to these various temperature arrangements because each field produces a different reaction A neutral bath aims to avoid a reaction either to heat or cold therefore the temperature should be between body and skin temperature If the water is warmer than body temperature there will ensue a reaction due to heat if it is lower than skin temperature the reaction will be that due to cold.

For practical purposes the temperature of a full hot bath may range from 102 to 105 F (38 9 to 40 6 C) A bath over 105 F (40 6 C) should be regarded as very hot and should be used only for pur

temperature water would be intolerable Lampert[11] and Zeiter[12] mention various theories which have been offered to explain this phenomenon that a layer of vapor prevents a too rapid transference of heat to the skin that the initial layer of paraffin acts protectively and that actually less heat comes in contact with the skin than is indicated by the temperature reading of the hot paraffin

Lampert believes the last theory to be sound on account of the physical character of heat capacity and consequently heat transference. He states that paraffin has only one third the heat capacity of water that less heat is transferred to the skin and that therefore the skin can tolerate an application of paraffin of a much higher degree than that of water, the ratio being about 135 and 115 F (57.2 and 46 1 C)

Electric Cabinet Bath.—The electric light cabinet is found in most physical therapy departments The unit usually contains between 40 and 50 mazda or carbon lights has mirrors or reflecting material on the inside and is so arranged that while the patient s body is subjected to the influence of the lights his head is outside of the cabinet. This offers very definite advantages over the old fashioned Turkish bath or steam room. These are some of the advantages It combines both radiant light and convective heat. Light is used because of its penetrability of soft tissue, thereby hastening the process of perspiration. This frequently can be induced in from five to ten minutes with a cabinet temperature of less than 105 F (40 6 C) The significance is that, compared with a hot air or steam bath the electric cabinet bath causes less strain on the heart. The patient is more definitely under the control of the nurse a fact very important in advanced cardiorenal cases where elimination is desirable. The pulse rate can readily be taken and the heart action controlled by cold applications to the head The blood can be further diverted from the head by means of a hot foot bath given at the same time

Diathermy —Prolific literature on the clinical use of diathermy has developed and favorable results have been reported for a great variety of unrelated conditions Unfortunately many of these favorable reports are based on uncontrolled and exceedingly fallacious clinical evidence Its wide use has resulted partly from its appeal to the imagination of physicians and laymen as something quite extraordinary and partly from the hope that it might be helpful though not understood So far as we know the effects are due entirely to the heat developed and such fanciful phrases as cellular massage" etc are of no help to our understanding. Diathermy is a valuable method of applying heat, but should not be regarded as a method which cures a disease but rather as a useful measure wherever heat is indicated

The theories of selective heating, specific bacteriologic effect and specific electric effects emanate for the most part from workers in

tween skin and water Contrary to the general conception that a cold bath should not be taken while the body is heated it is scientifically established that such a procedure is not only not harmful but it is advisable It should definitely be noted that it is unwise to prescribe a cold shower when the skin temperature is low because it lessens the chance for the desired tonic reaction

Prolonged cold bathing as practiced at the seashore and pools may become harmful when the individual continues to feel chilly Extended immersion in cold water may be followed by a considerable drop in bodily temperature and concomitant lowering of resistance.

Contraindications to the Cold Bath.—There are bodily conditions which preclude the probability of a proper reaction to shock deliberately planned There can be no reaction without a previous shock. In this category are coldness of skin temperature prolonged cold bathing sensitivity to cold active tuberculosis severe physical and mental exhaustion shock, infancy and senility Cold baths are also contraindicated in hyperthyroidism since they stimulate an already high basic metabolism.

Special Reactions to Heat and Cold

In order to alter tissue temperature materially the heat regulating mechanism of the body must be defeated The details of the mechanism are still being investigated, but the fundamentals are fairly well understood and can be found in any standard text of physiology Heat is lost by radiation from the skin and mucous membranes especially the respiratory mucous membranes. Heat loss occurs also by evaporation of moisture from these surfaces and by way of the urine and feces

The amount of heat loss varies from minute to minute according to the amount required to maintain the physiologic normal temperature The use of the various avenues of loss also varies according to changing conditions. These changes are controlled by the vasomotor mechanism the sweat mechanism and the respiratory center Heat production is under the immediate influence of the motor nerve centers and the various mechanisms of stimulation of metabolism Practically all the physiologic effects of application of heat or cold are an expression of the endeavor of the heat regulating mechanism of the body to maintain its constant temperature

The manner of applying heat or cold may produce a local, systemic, or a reflex action If heat is applied locally we may expect the following effects in the area treated It allays irritation of the peripheral nerves very effectively by a mechanism not well understood It dilates the cutaneous blood vessels increases the secretion of sweat, relaxes muscles and other soft tissues, and aids in absorption of exudates Heat exerts reflexly some influence on the nutrition of the

poses of creating a fever Hot baths should not be given in arteriosclerosis milder forms of cardiac decompensation tabes, spinal and cerebral organic diseases and possibly hemorrhages

The Hot Foot Bath.—The hot foot bath has long been employed for the relief of pain. It is well to start the bath with a temperature comfortable to the patient and gradually raise it to the point of tolerance. The duration of the bath need not extend beyond twenty minutes at which point the optimum therapeutic value will have been obtained

The Contrast Bath.—The contrast bath is a modification of the hot foot bath and is especially useful in painful conditions of the foot accompanied by poor circulation The foot is placed alternately in hot and cold water So that one may get the greatest physiologic effect it is desirable to have as great a range of temperature as possible the hot water of as high a degree as may be borne and the cold as low as may be obtained The foot is placed in the hot bath for from three to four minutes then plunged in the cold for a minute or less. This is repeated four or five times

The Whirlpool Bath.—The hot whirlpool bath had its origin in the first World War and has found increasing favor in this country especially so with athletic trainers The agitation of the water increases the thermic impressions on the skin surface and on the circulation The bath has a sedative effect, relieving painful and swollen joints and permitting more effective massage and joint movements.

Extreme care should be exercised in prescribing any kind of local hot baths or other heat applications in the presence of nerve disturbance. Also an individual finger should never be subjected to local hot applications. It is safer to submerge the whole hand

The Short Cold Bath.—Cold baths usually mean the application of water to the body from one-half minute to three minutes at a temperature varying from 80 to 50 F (26 7 to 10 C) and even 40 F (4.4 C)

The reaction to a short cold bath is definitely stimulating and is therefore customarily referred to as a tonic bath. Cold water on contact with the skin stimulates the cold spots causing impulses to travel to the nerve centers in the spinal cord and brain which in turn modify the vital functions of tissue and organs This phase of the application is called the reaction and is accompanied by a reddening of the skin and a general well-being of the patient. This reaction should follow a cold bath If it does not, the bath is harmful

The colder the water the greater is the shock and subsequent good reaction provided always that the individual reacts well to the cold It is recommended to increase gradually the temperature range be

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superficial tissues on underlying organs, and on remote areas in a manner not yet fully understood

Vasomotor changes, due to sympathetic nerve action, may be noted in areas not primarily affected by temperature change Thus im mersing the feet for thirty five minutes in moderately hot water increases the rate of blood flow in the hands by diminishing vasocon strictor tone in the upper extremities Vasodilation so produced is almost as complete as the resulting sympathetic ganglionectomy but persists only as long as the patient feels warm Immersing the forearms will produce similar results in the lower extremities.[26]

The local rise in temperature is limited because of rapid diffusion of heat throughout the general circulation We[27] have noted that when the uterine adnexa was heated to 112 F (44.4 C) there occurred a sudden fall in temperature as recorded by urethral, cervical and rectal temperature, and synchronous with this drop a concomitant rise in body temperature We have noted that if the uterine temperature was allowed to rise to 114 F (45 6 C) the patient complained the next day of discomfort in that area, probably due to a slight degree of tissue damage

Cold applied over the trunk of an artery causes contraction of the artery and of its distal branches For example ice bags applied over the carotid arteries decrease the blood going to the brain and head generally Such an application is called a proximal application

Prolonged immersion of the hands in cold water causes contraction of the vessels of the brain and nasal mucous membrane

An ice bag applied to the precordium slows the heart rate increases its force and raises arterial blood pressure.

Long cold applications to the face forehead scalp and back of the neck cause contraction of the blood vessels of the brain

Ice bags applied to the sides of the neck and the upper dorsal region contract the blood vessels of the pharynx and the nasal mucous membrane.

Bisgard and Nye[9] have recently published the results of an inter esting, instructive and timely article on the influence of hot and cold applications upon the gastric and intestinal motor activity Ice packs applied by covering the abdominal wall with ice bags caused vigorous motor responses in all three segments of the gastro-intestinal tract. Hot packs applied to the abdominal wall had an inhibitory influence upon the gastric motor activity' The clinical application of their findings should be of considerable value to physicians and surgeons in whose domain falls the treatment of inflammation of the intestinal tract. 'If it is beneficial they conclude, "as is generally believed that the gastro-intestinal tract be inhibited and placed at rest in so far as possible in the presence of inflammatory lesions such as appendicitis and peritonitis and bleeding lesions such as bleeding peptic ulcers then hot applications and not ice bags are indicated Their work on

the influence of heat and cold applied both internally and externally is summarized by their conclusions

Gastro-intestinal motor activity is inhibited by the application of heat to the abdominal wall and by iced water taken by mouth It is stimulated by the application of ice to the abdominal wall and by the ingestion of hot water by mouth.

External cold applications increase gastric acidity increasing both free and total acids In a subsequent publication it will be proposed that this response be utilized in the test for true achlorhydria By simply immersing the hands in iced water for a few minutes a response similar to that resulting from the subcutaneous injection of histamine can be obtained.

The ingestion of iced water diminishes the secretion of acids by the stomach.

Penetration of Heat and Cold—A number of interesting papers have been published in recent years bearing on the subject of the temperature changes due to hot and cold applications Selling Brill [11] measured intraperitoneal changes in temperature accurately with a thermocouple and galvanometer and found that ice bags gave little effect, the greatest being a fall of 2 5 C (4.5 F) The hot water bag and electric pad gave no appreciable change

Leyton and Sherrington [40] showed that an ice cap or hot water bag applied to the scalp might change the intradural temperature of the rabbit 5 to 6 C (9 to 10 8 F)

MacLeod [41] with a thermocouple in rabbit muscle 17 mm beneath a hot water bag applied to the surface got a rise of 4 C (7 2 F) With the thermocouple placed just inside the intraperitoneal cavity and with an electric pad placed over the surface of the abdomen there was a rise of 4 C (7 2 F)

Stengel and Hopkins [42] record a fall of 1 C (1 8 F) on a thermocouple placed in the human stomach by way of a Rehfuss tube *after forty five minutes of application of an ice cap over the epigas* trium A hot water bag over the epigastrium gave very little change in temperature

Bierman [8] reports that temperature was diminished as much as 26.4 F by applying ice bags on each side of the human calf

Crymotherapy—Early in 1938 Fay and Henny [22] published their experience of a method for reducing body temperature both local and general on twenty-seven cancer patients for its effect on tumor formation and the relief of pain. It is unfortunate that in referring to this newer method of therapy various names have been applied i e artificial hibernation human refrigeration frozen sleep and "crymotherapy" I thoroughly agree with Kovács [44] that the terminology may be simplified by using a term which is analogous to medical and surgical diathermy He suggests the term surgical hypothermy

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pressure in contrast to the usual drop observed in all of their other patients who were hypersensitive to cold. The authors conclude as a result of their experimental studies that a histamine-like substance is liberated in the skin following exposure to cold this substance when carried to the general circulation produces a reaction characteristic of histamine It has been suggested that occasional sudden deaths of good swimmers upon plunging into cold water may quite likely be due to the effect of the cold water on the body producing a chemical substance whose action resembles that of histamine

The Test for Hypersensitiveness to Cold.—Adson and Allen[1] have devised a simple test to determine hypersensitiveness to cold. The hand is immersed in water at 10 C (50 F) for five minutes Prior to immersion of the hand in the water observations on the blood pressure and pulse rate are made and observations are continued at intervals of one minute while the hand is immersed in the water and for a period of twenty minutes after the hand is removed from the water If swelling of the hand occurs after it has been removed from the water the indication is that the patient is hypersensitive to cold A systemic reaction is indicated by a drop in blood pressure an increase in the pulse rate and flushing of the face We are of the opinion that all subjects who demonstrate a systemic reaction would develop symptoms of collapse if they swam in cold water'

Adson and Allen believe that patients who are hypersensitive to cold are amenable to treatment. Systemic desensitization to cold can be accomplished in two ways first by having the patient immerse the hand in water at 10 C (50 F) for from one to two minutes twice a day for three or four weeks a procedure which is sufficient to desensitize the average subject second patients also can be desensitized to cold by subcutaneous injection of 0 1 mg or less of histamine twice daily for two to three weeks

Inflammation and Infection

Inflammation has been broadly defined by Menkin[45] as a complex vascular lymphatic and local tissue reaction elicited by the presence of micro-organisms or of nonviable irritants The inflamed area is shunted off from the rest of the organism it has its own metabolism hydrogen ion concentration and modified circulation In an inflamed area the striking features are the marked dilatation of the vessels the slowing or even complete stoppage of the local circulation together with the exudation of serum and the migration of leukocytes Pain is due to pressure on the nerve endings by toxic irritating products

The local application of heat and cold in various conditions of inflammation and infections is still done largely empirically Generally speaking cold acts by restricting exudation and bleeding reducing cellular activity and relieving pain by desensitizing nerve response

or "crymotherapy" be used for describing the use of cold for local tissue destruction, such as freezing with carbon dioxide pencil or paste, while 'medical hypothermy' could designate the use of cold compress or an ice bag over a circumscribed body area.

Not enough conclusive evidence has yet been published to warrant great enthusiasm for this therapy Certainly it has not yet advanced far enough for use by the general practitioner for the treatment is not without danger and should only be done under specialized supervision and in a hospital where the proper facilities for carrying out this rather elaborate procedure are available

Chilling of the Body Surfaces.—A study has been made by Taylor and Dyrenforth [43] to determine the effect of prolonged exposure to cold on loss of body heat. They observed the effects of chilling on 250 children of approximately the same age taking their temperatures before and after a period of forty five minutes devoted to swimming in an indoor pool with a temperature of the water at 73 F (22.8 C.) It was found that of this number only 30 maintained a normal temperature whereas the readings in the remainder of the children showed a drop in some as low as 95 F (35 C.) Their conclusions are that the chilling of the body surface induces peripheral vasoconstriction a low leukocyte response and impairment of the phagocytic capacities of the fixed tissue cells including that of the nasal mucous membrane. One may assume that one of the immediate results of these changes is a predisposition to induce respiratory disease in those who already harbor respiratory infections, especially in the sinuses and the middle ear

Allergy to Cold.—Occasionally there are found persons who are hypersensitive to cold air or water and react either locally or systemically The objective clinical manifestations may be a change in blood pressure and pulse rate. There may be severe headache painful and stiff joints a rise of temperature and severe urticaria as reported by Kile and Rusk.[34]

The Cold Pressor Test for Stability of Vasomotor System.—This is a test designed by Hines and Brown [28] to measure the reactivity of blood pressure of normal and hypertensive subjects the stability of the vasomotor system The cold pressor test reveals inherent instability of the vasomotor mechanism and thus indicates often prior to the development of persistent hypertonia, the vulnerability of the individual. The usual response is that shortly after the hand has been immersed in cold water at 40 F (4.4 C) there is a sharp drop in the systolic pressure which returns to almost normal at the end of the 8 minutes immersion.

Horton and Roth [31] more recently have reported a case in which the usual response to cold was characterized by a marked rise in blood

trate deeply enough to even in the minutest fashion influence retardation of the inflammatory processes nor does it inhibit the intestinal peristalsis but on the contrary stimulates this movement. As Bisgard and Nye[9] and others have conclusively demonstrated this reaction this should do much to put this controversial subject on a rational basis Furthermore the prolonged use of ice bag in appendicitis may do harm through its anesthetic effect by suspending warning stimuli and thereby make the detection of tenderness hyperesthesia and muscle spasm more difficult Neither does heat influence directly the progress of the inflammation Heat acts reflexly by relieving pain and spasm and by lessening the peristalsis wave. It has a salutary influence on the patient.

Arthritis

In discussing the treatment of arthritis it is difficult for us to think in terms of heat only and invariably to associate with it other physical measures which have proved of value. We refer especially to the proper use of rest, exercise massage and heliotherapy Since it is not within our province to discuss these measures we refer the reader for further details to other appropriate chapters in this volume dealing with these subjects

It is also difficult for us to think of treating arthritic patients by local heat applications alone as we always include a general systemic treatment for its physical reactions as well as for the effect it has upon the patient s morale. This is especially true since many of these various measures may very successfully be carried out at home. Such hydriatic procedures as the full tub bath the shower contrast foot bath and the full wet pack are examples We may also add the homemade baker electric pad and infra red

In prescribing home treatment a definite difficulty arises which has reference to the intensity of heat. A general idea seems to be abroad that whenever a local application of heat is indicated it should be given as hot as possible. We thoroughly disagree with this false impression and take special care to inform our patients that whatever the application may be it should be a comfortable heat and that anything beyond that should be strictly avoided

In addition to the above-named measures many hospitals employ modalities which cannot be used at home and which have proved to be most effective We have in mind the Scotch douche electric cabinet bath Hubbard tank, whirlpool and paraffin baths short wave diathermy sinusoidal current and iontophoresis

In our experience the Scotch douche that is the application under pressure of alternate hot and cold water and when preceded by an electric cabinet bath has given us by far the greatest satisfaction It acts as a metabolic uplift, hastens the general bodily circulation tones the musculature and in general imparts to the patient a feeling of well being unequaled by any other treatment A fair substitute is the

Heat applied locally lessens irritation of the peripheral nerves, hastens the return lymph and venous circulation, aids in the absorption of exudates and relaxes soft tissues

In applying local heat to inflamed surfaces many surgeons prefer a hot stupe until such time that the tissues appear to be saturated, after which dry heat, preferably in the form of infra red is more effective.

In infections of the hand or foot it is important to decide whether or not surgical intervention is indicated If the infection is an acute, rapidly spreading process, it demands conservative treatment It is generally believed that to cut into an area of intense inflammation and cellulitis before nature has had sufficient time to wall off the infective process is a mistake If there is any doubt about the type of treatment to be used it is wise to stay on the side of conservatism and aid nature in localizing the infection by applying large warm wet sterile dressings until the spreading has localized and abscesses have formed It is timely to call attention to the harm which may follow the usual home treatment of soaking an infected finger in hot water without using the entire hand as an indicator of safe water temperature. Failure to do so may result in gangrene

The question of a possible specific effect of short wave therapy on pyogenic infections has been the subject of discussion for the last several years more especially in such infections as furuncles, carbuncles empyema and lung abscesses. European writers are prone to show more enthusiasm than do American writers, so much so that the conservative physicians of this country who are well acquainted with the use of diathermy look askance upon the numerous reports which have emanated from foreign workers abroad. For example Brugsch and Pratt [13] have published a statistical survey supporting this thought. They found about eighteen foreign workers reported having treated 129 cases of lung abscesses and that 87 or 67 per cent, made a satisfactory recovery but that several American physicians have attempted this procedure without favorable results

As this may be misleading it will serve our purpose best to have an open mind on the subject until further well-controlled clinical evidence is available such as the work which Schmitt [14] has published Some of his conclusions are the following

"The chief indication for short wave diathermy is the presence of inflammation The chief contraindication is edema. This indication and contraindication are inseparably joined together The desired physiologic effect is the establishment and maintenance of an active hyperemia Tolerance of inflammatory tissue for heat is always less than that of normal tissue therefore it is an unreliable and unsafe guide for determining the power input per unit tissue volume." He believes the greatest danger of short wave diathermy is overheating

In the presence of peritonitis or appendicitis the application of ice bags to the abdomen is based on a false premise Cold does not pene

Furthermore it is possible that some other toxic substances the nature of which is not yet known may be removed at the same time It is well recognized however that the degree of toxicity does not run precisely parallel with the accumulation of nitrogenous substances Thus, patients with uremia may show a disproportionately small rise in the urea nitrogen on the other hand patients with marked increase in the urea nitrogen may present few or no clinical evidences of intoxication

He states further "The argument has been advanced that, in the presence of toxemia from renal insufficiency and retained nitrogen sweating serves only to concentrate the blood and to add to the danger from the retained substances But he says There is some doubt as to the validity of this, however as the blood maintains its water balance with great tenacity drawing on the tissues for this purpose the evidence is not final that under conditions of ordinary therapeutic procedure the blood undergoes any true concentration. Furthermore in the absence of inability to excrete water there would seem to be no objection to the administration of fluid to prevent concentration as is indeed the practice in many hospitals It is to be borne in mind however that the elimination of water constitutes one of the functions of the kidney O'Hare [46] points out that a further burden may be added and even pulmonary edema may arise from undue administration of fluids'

The manner in which systemic heat may be supplied is of no great consequence One may employ the hot or cold pack or the electric light cabinet bath if institutional care is available One may improvise a cradle containing eight or ten electric light bulbs which can be covered with blankets to retain the heat. This cradle placed over the patient while he is in bed affords very satisfactory means of bringing about perspiration The efficacy of the treatment is enhanced by producing an air current with the aid of a small fan

Pelvic Heating

The hot water vaginal douche has long been used as a cleansing agent and as a means of heating the pelvis Perhaps too little attention has been paid to the harmful [47] effect this may have of constantly washing out certain material that nature is depositing from the vaginal walls and the acid bacillary bacteria which maintain a barrier to vaginal infections In prescribing the hot douche for the purpose of heating the pelvis this fact should, therefore be noted As a heating agent its value must be regarded as of minor consequence but if used at all the application should be carried on at least for thirty minutes using water of no higher temperature than 110 F (43 3 C) and taking care not to cause too great pressure Considering the hot douche as an adjunct to the curbing of infection as stimulating the natural barrier to tissue infection it is of little value since the necessary high

alternate hot and cold shower at home It has been our practice to prescribe the hot full tub bath at from 102 to 105° F (38 9 to 40 6 C) for a period of from ten to fifteen minutes, thus creating a slight rise of body temperature. The patient is then put to bed for an hour and may then take a moderately cool shower

In an electric cabinet bath the patient sits in a comfortable position with the entire body, with the exception of his head exposed to light radiation This is an excellent unit for applying systemic heat. We have made it a practice always to follow it by either a needle bath or a Scotch douche

The Hubbard tank is somewhat larger than a bathtub and used principally so as to allow appropriate arm and leg movements to be done while in the water which has a temperature of from 98 to 100° F (36 7 to 37.8 C.)

Whirlpool and paraffin baths are described elsewhere

Short wave diathermy may be used both locally and for systemic effect. Here, as elsewhere in our writing we wish again to emphasize the extreme caution which must be used when this modality is applied locally to joint conditions so as to avoid overheating

The sinusoidal current is an electrical device used for the purpose of bringing about muscular contraction without necessarily moving the joint. If properly done this is an excellent means of contracting the muscles and an excellent adjunct to heat and massage.

Iontophoresis is a method of projecting drugs through the skin into the body by means of a galvanic current.

The question of exercise and rest in patients afflicted with arthritis is a controversial one which may be answered by the statement that all rest and no exercise is as bad as too much exercise and not sufficient rest. Krusen [37] has collected various arguments both pro and con, from the many writings which have appeared in recent years I heartily recommend this text to anyone interested in the use of physical therapy in arthritis

NEPHRITIS

The empirical use of the systemic application of heat in the treatment of nephritis has long been regarded as a proper method for excreting nitrogenous material through perspiration. Although the method has not yet been rationalized there seems to be evidence to substantiate the correctness of the theory Pemberton [34] has the following to say on the subject 'Whatever other pathologic manifestations may accompany nephritis certain symptoms demanding treatment are apparently dependent on the retention of toxic material possibly of a nitrogenous nature salt or water and acid products of metabolism, especially phosphates and sulphates. Some workers doubt the vicarious removal of nitrogenous substances through the skin when elimination through the urine is reduced but clinical experience is in favor of the view that something of this nature may occur

More recently Newman [47] has perfected a device using air heated to a temperature of 130 F (54.4 C) which is circulated through a special-shaped thin walled rubber bag not unlike that used in connection with the Elliott unit. This bag is inserted in the vagina in a collapsed state and then inflated with hot air so as to distend the vagina. We have had no experience with this device in our gynecologic service.

An effective procedure of heating the female pelvis is by means of diathermy In using the long wave conventional diathermy machines it is necessary to place applicators in the vaginal vault as well as about the pelvis From time to time different electrodes have been put on the market by which when properly applied one may expect the pelvic tissues to be heated to 110–115 F (43.3–46.1 C) Although effective the objection to this method is the necessity of using the electrode intravaginally which as has been stated before is unpleasant to the patient.

With the advent of short wave diathermy we have at our disposal a simple easily applied and effective agent to produce deep tissue heating A number of technics may be used but probably the simplest method is the use of a magnetic induction coil in the form of a pancake which is placed on the lower abdomen Further details regarding the technic may be found in the chapter on Medical Diathermy"

Indications.—The use of deep-seated heat should be employed with discretion not indiscriminately and as an adjuvant to other orthodox therapy It is generally believed that whatever benefit may accrue because of its use is due to the influence of heat in hastening local circulation thus promoting absorption of inflammatory exudates in relaxing muscular tension and perhaps in some way reinforcing the normal forces of resistance to bacterial invasion. It relieves swelling chronic stasis and pain In any selected case it may be given a trial and if followed by a rise in temperature further heat treatment should be postponed. Furthermore it is the consensus of many conservative workers in this field that diathermy is purely a form of heat without selective potency or bactericidal property

Heat in various forms has been advantageously employed in the following conditions of the pelvis nonspecific inflammations Neisserian infection thrombophlebitis inflammatory tumors of the adnexa adnexitis parametritis pelvic cellulitis and acute inflammations

It should not be used in the presence of complicating pelvic conditions such as myoma uteri and ovarian cysts or tumors pregnancy menstruation, bleeding of inflammatory origin or acute stages of specific endocervicitis

Cold Applications.—Pelvic pain inflammatory or otherwise is usually helped by applications of heat and yet there are individual conditions which seemingly do better when subjected to cold For this

temperature to be effective may also cause tissue damage Water at a temperature of 110 F stimulates an increased blood flow throughout the pelvis and may be of some value in checking pelvic cellulitis and parametritis associated with salpingitis So as not to disturb the normal acidity of the flora as represented by pH 4 5 the water may be acidulated by adding three tablespoonfuls of acetic acid one of lactic, five of boric and two of citric to the quart of water Such a douche in order to be effective should be given at least twice a day

Hot water bottles, the well known electric baker and the electric pad may be used to good effect for superficial indications Care how ever should be exercised to avoid burns especially with the electric pad Probably the old fashioned, but somewhat forgotten sitz or hip bath and the hot stupes and fomentations are the most comforting and satisfactory methods of home treatment. (See chapter on 'Hydrotherapy')

The Elliott unit[39] is a device consisting of a certain soft rubber blunt forked-shaped vaginal bag which is inserted in the vault. To this bag is attached an intake and outflow tube from the machine which heats and circulates water at a temperature of as high as 135 F (57 2 C) through the circuit. It is true that the pelvis can be satisfactorily heated and that favorable clinical reports have been recorded but the technic is cumbersome oftentimes uncomfortable to the patient, not devoid of danger of burns, and in no way superior to short wave diathermy Most gynecologists are averse to application of any heat which necessitates the introduction of any sort of instrument into the vagina.

Gynecologists who employ heat in one form or another for pelvic conditions are definitely divided in their opinion as to the use of the Elliott treatment. Those favoring it are usually enthusiastic and almost without reservation employ it in all kinds of acute inflammations. This is contrary to the teachings of the conservative school of thought which distinguishes between an acute pelvic cellulitis which in all probability will not go to frank pus but will subside with the use of bed rest and chemotherapy such as sulfanilamide and sulfathiazole and other supportive treatment. The use of extensive forced pelvic heat should be reserved for those cases in which a pelvic abscess will develop frank pus which may be localized by the heat and subsequently drained by cul-de-sac puncture Such cases respond to chemotherapy less dramatically than the cellulitis group and heat is undoubtedly of benefit in localizing the pus for surgical drainage. Certainly our experience in conjunction with various members of our clinical staff subscribes to this dictum.[40]

We do not favor the Elliott treatment, not because it fails to heat the deep tissues of the pelvis but because the technic is cumbrous distasteful to the patient and certainly not without danger of burns. Furthermore we feel that we can more easily and equally effectively heat the pelvis with modern short wave diathermy

application of heat in the early stages We believe however that the application should be repeatedly interrupted by a cool sponging which will tend to hasten the circulation and counteract what might result in a venous stasis The heat itself has a salutary effect upon the patient in that it relieves pain but an application of an hour or more of an infra red lamp might very well tend to cause a venous congestion which is not desirable What is wanted is a physical measure which will help the return circulation We believe alternate heat and cold will do this better than will continuous heat Caution must be exercised in not using heat of too high an intensity else the vasomotor apparatus may be upset and hence defeat the purpose of the application which is to hasten the circulation

In the matter of applying local heat to an extremity for example a hot foot bath the temperature should be selected with great caution It is our opinion that there is a general belief both with respect to the layman as well as the medical profession, that the higher the temperature the more effective will be the result. This is a wrong concept. Under no condition need the temperature exceed 110 F (43 3 C) If there is a moderate impairment of nerve and blood vessel tissues the reading should be lowered to 101 F (38 3 C) If there is severe impairment of these structures heat in any form will be of little or no avail because of a failure of the blood vessels to respond. Under these circumstances extreme care must be exercised to guard against any form of trauma, including burns

A safe method of applying heat is the well known infra red cradle with carbon lamps and thermometer or warm fomentations Diathermy should be used only by those with experience and then only with extreme caution because a burn is more easily produced and very much more difficult to heal than elsewhere If diathermy is used it should not be applied to the extremities direct but rather to the abdomen and pelvis

For the relief of pain in peripheral vascular diseases of an advanced nature Starr[424] has found that the optimum environmental temperature would be 91 to 95 F In the case of a foot bath this is referred to as neutral and is within the range of skin temperature of normal feet.

Bone and Joint Conditions

As early contusions muscle strains sprains and dislocations are usually accompanied by hemorrhage it is advisable to apply cold compresses or a cold foot bath as soon as possible If it is an ankle sprain which is being treated it is well to apply a pressure bandage to limit the swelling It should be emphasized that in the early stage of these injuries heat is contraindicated Heat is always contraindicated in the presence of hemorrhage for fear of increasing the bleeding and the possible development of a calcified hematoma. This condition is commonly met in a condition known in athletic circles as Charley

purpose the sitz bath is first choice In this connection Crossen[17] stated that he used it "not as a sedative but as an active stimulant to the pelvic organs. The temperature for the first bath should be about 70 F the succeeding baths gradually lowered to 50 F and for a duration of from five to twenty minutes depending on the patient s reaction. If this is unfavorable the baths should of course be discontinued The reaction is enhanced by prompt drying and brisk rubbing" In some cases in which amenorrhea is due to local loss of tone or imperfect development Crossen has found the cold sitz bath more beneficial than the hot.

Respiratory Diseases

We have found the use of infra red to be of great value in treating the common head cold A one hour application of infra red the lamp being placed at a comfortable distance will do much to induce drainage relieve the congestion and lessen the headache The prognosis is more hopeful in the earlier stage

In cases of chronic sinusitis it has been our observation that the short wave is far superior to infra-red. Further our cases warrant the unreserved statement that in chronic sinusitis short wave is of definite help in the relief of pain. The treatment need not continue for more than ten to twelve minutes. If possible the sinuses should first be washed before the short wave is applied.

In bronchitis bronchiectasis and emphysema a moist chest compress has been a time-honored home remedy Many hospitals have been using the short wave instead with gratifying results The deep heat relieves the pain in the chest and promotes expectoration of the secretions Our experience in treating asthma thus has been very favorable

There are some who favor the use of the short wave as an adjunct in the treatment of pneumonia. It is claimed that it reduces thoracic pain lessens cyanosis that usually follows the treatment, and materially decreases the convalescent period. All this may be true as stated but the fact remains that these conclusions are not accepted by the vast majority of physicians who are especially qualified to judge Though these men doubt very seriously that the progress of the disease can be favorably influenced by the application of the short wave they concede the claim that the patient may be made more comfortable Also it has been pointed out that the increased blood flow produced by the heat may tend to spread the infection. It is safe to say that the conservative physician will delay using the short wave pending reports more conclusive than those thus far advanced.

Peripheral Vascular Diseases

Peripheral vascular diseases of the extremities including thromboangiitis obliterans diabetic gangrene Raynaud s disease and intermittent claudication are conditions which seemingly respond well to

sive and active movements muscle setting and the use of the low voltage wave

Tenosynovitis

This condition is usually found in the tendons of the wrist of the forearm especially in tennis players and in the Achilles tendon Tenosynovitis is an intractable condition and frequently resists all forms of heat treatment unless the parts are at the same time satisfactorily placed at rest. This may be done by proper splinting or by the appli cation of adhesive strips in order to place the tendon affected in a neutral position Rest is the treatment par excellence plus the addition of a mild form of heat as mentioned elsewhere It is preferable not to use the short wave because of tendency of overheating

Fibrositis and Myositis

Fibrositis and myositis are commonly found in the muscles of the shoulder girdle and lower back. These painful and disabling conditions are best treated by prolonged mild heating massage and proper support. The selection of the type of heat is of no great significance. Our experience seems to indicate that the short wave diathermy is superior to either the infra red the moist heat, or the application of hot paraffin because of deeper penetrability Convalescence may be hastened by following this with massage or the sine wave muscular contraction.

Neuritis

The prolonged mild application of any type of heat in neuritis is usually comforting to the patient. The short wave diathermy is un questionably of greater service in inflammation of the nerves than is superficial heat. We have occasionally encountered cases where the application of heat caused the pain to become more intense. If the condition is aggravated after trying the application of heat once or twice then heat should be discontinued and cold used instead

Gastro-intestinal Diseases

In acute enteritis spastic colitis and simple catarrhal jaundice the application of some form of heat to the abdomen gives great comfort to the patient. Even a heating pad or hot water bag kept on the abdomen for a matter of hours has a very salutary effect The electric heating pad per se is not objectionable However there have been reported a considerable number of burns resulting from either a short circuiting of the wires in the pad or the too prolonged application due perhaps to the patient s falling asleep

Recently Zeiter [70] has reported his observations of a study of the use of diathermy in treating the irritable colon which term includes

horse" and so frequently mistreated by the early application of heat and massage. It does not seem to make a great deal of difference what kind of heat is used although it should be said that there is a tendency among athletic trainers to prefer the whirlpool bath rather than the hot foot bath because of the additional mechanical massage produced by the whirling of the water and the stimulating effect on the peripheral nerve endings

In the treatment of bone and joint conditions one may also make use of the paraffin bath the technic of which has been previously mentioned the infra red and the more modern short wave diathermy are also applicable

Bursitis or periarthritis of the shoulder is a common disability which the general practitioner has to meet In these conditions and those following an injury there soon develops a spasm of the shoulder girdle muscles resulting in a limitation of motion This is nature's defense mechanism to guard against motion which in turn produces pain Unfortunately the position of greatest ease seems to be with the arm held close to the body or carried in a sling a position which frequently leads to the development of adhesions shortening of the adductor groups and greatly increasing the disability and rate of recovery Our experience leads us to believe that in all shoulder injuries or acute inflammation of the shoulder joint it is well to place the arm in an abduction position either by putting the patient in bed or causing him to sit at a table with the arm supported on pillows A still better method is the use of an airplane splint.

The application of heat is of course important. Here again it does not seem to make much difference what type is employed but because of the ease with which the infra red apparatus may be handled this type is perhaps used most frequently The short wave diathermy if available is however the first choice provided a low intensity is used When neither of these is available the application of hot towels or as has been stated before in the discussion of other joint conditions hot paraffin is recommended

The functional treatment of fractures by means of heat, massage and mobilization is now a universally recognized procedure Heat is not used directly over the fracture site but some distance away preferably over a heavy muscle mass The importance of heat lies in the fact that it hastens circulation and prepares the soft tissues for the massage and whatever exercise the patient may take which should follow the application of heat. There is some question of the advisability of prolonged heating over the fracture site because of the possibility of a retardation of the healing process Blair [6] believes that the prolonged use of heat in recent fractures is a wrong practice feeling that the hyperemia produces resorption of the bone He believes alternating ischemia and hyperemia maintains normal calcification of bone and therefore aids in the healing of fractures Our own experience is the use of a mild form of heat followed by massage pas-

sitz bath infra red and diathermy Concerning the last a number of special electrodes have been devised but which we believe are used only to a very limited extent by urologists The conditions which may be relieved by heating are chronic prostatitis prostatic abscesses *seminal vesiculitis orchitis and epididymitis In the last two conditions* many surgeons prefer in the earlier stages at least cold applications.

Rectal Disease

Painful rectal conditions such as thrombotic hemorrhoids fissures etc. are helped by heat. The pain can often be relieved by a hot compress which must be changed frequently or kept warm by some heater (infra red unit) applied to the outside of the compress. Keeping the compress continuously heated has the advantage of avoiding the painful manipulation of changing The sitz bath is a convenient form of applying either heat or cold Short wave diathermy when available is recommended

Shock

In this condition the time-honored application of systemic heat is still in order An efficient and exceedingly simple method is the full tub bath at a temperature of from 100 to 102 F (37.8 to 38 9 C) The addition of a small amount of mustard enhances the physiologic reaction Other methods are the use of the homemade electric cradle or baker and if available systemic heating by diathermy

Sunstroke and Heat Exhaustion

This condition sometimes called heat stroke or heat pyrexia, is characterized by a temperature of 100 F (37 8 C) and higher and calls for immediate action aiming to reduce the temperature The procedure most commonly employed is an ice water tub bath a method with which we cannot entirely agree We believe it may actually interfere with the loss of heat. It is axiomatic that a healthy reaction of a person to a cold bath is his ability to react to the exposure in such a way that the peripheral circulation will be greatly augmented by virtue of the greater volume of blood carried to the surface If the patient does not react, the condition then is similar to shock. The extremely low temperature of ice water quite likely interferes with heat loss from the skin blood vessels by constriction by the stimulation of the cold nerve endings Furthermore the chill thus produced may reflexly induce shivering which in turn creates still more heat *Persons well versed in hydriatic procedures oppose the ice water treatment.* They believe that the reduction of temperature is best served by subjecting the patient to a 70 F (21 1 C) water temperature

The only indication for an ice treatment is certain pathology of the brain when the heat center is subjected to gross interference

colitis, spastic constipation, mucous colitis and unstable colon He found that 'diathermy is a beneficial adjunct in the treatment of irritable colon.

Multiple Sclerosis

The application of heat be it mild or fever therapy, has not been attended with any great degree of success On the contrary, we have noticed in some patients that the treatment was followed by a definite sense of weakness with no lessening of stiffness or improvement in muscular coordination This observation is in common with Simons [60]

Skin

Acute inflammatory dermatoses may be benefited by the use of cold applications in the form of cold wet pack sitz and foot baths This is especially recommended by Weiss [61] in ivy poisoning and the acute inflammation and edema on the hands and forearms due to the application of various irritating drugs Dermatologists employ a number of medicated baths without reference to thermal effect. These are fully discussed by Weiss

Diseases of the Eye

For the relief of pain and absorption of inflammatory by products, moist heat in the form of hot compresses, and dry heat by the use of infra red or short wave diathermy are useful especially if the lid or orbit is involved Heat is also useful in iritis and corneal ulcer When it becomes necessary to combat swelling or in acute conjunctivitis ocular bleeding and injury to the lids it may be more desirable to use cold compresses. In ocular syphilis and interstitial keratitis fever therapy has a very definite place.

Ear

The pain of otitis media may be allayed by heat applied in a number of ways Oily or glycerin ear drops warmed to the tolerance of the lip may be applied frequently The hot water bag is of some slight help Infra red applied at a distance of comfortable tolerance directly over the external auditory meatus for intermittent half-hour periods is usually helpful and comfortable to the patient.

Heart Disease

Cardiac and pericardial inflammations are treated with ice bags to the precordium. Heat is practically never used.

Disease of the Male Genitalia

In treating diseases of the male genitalia all forms of heat modalities have been used such as continuous hot rectal irrigation the hot

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Obesity

After a considerable number of trials we have come to believe that the time-honored procedure of sweating, be it the electric cabinet steam baths hot mineral baths or any other method of heating the body for the purpose of causing sweating and, therefore, a loss of body weight, is based on fake premise for the obvious reason that the poundage lost is due to loss of water which is restored during the following twenty four hours by the normal fluid and food intake

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CHAPTER THREE

TECHNIC OF ARTIFICIAL RADIATION

EDGAR MAYER, M.D

On first thought it seems peculiar that no standard technic exists for light radiation and that until recently little attention has been paid to dosage in treatment. On closer analysis however this is understandable because of the many existing variables not only in the source of light but also in the patient Light has been prescribed as a curative agent for many disturbances yet there is little proof that it is valuable in the majority of cases aside from rickets tetany osteomalacia, lupus, and a few other diseases. The empirical evidence strongly indicates its use in ulcerations many skin diseases infections of superficial surfaces and some forms of extrapulmonary tuberculosis but less so perhaps in anemias prevention of colds sinusitis epididymitis dental caries fractures etc. The skeptic may yet demand proof of action but inasmuch as doubt exists it is understandable why technic is so uncertain

REASONS FOR UNCERTAINTY OF TECHNIC

Variation in Lights.—Furthermore many sources of light exist with great variations in their spectral components limits and intensities. Prolonged usage of certain sources will even cause marked inconstancies in the emitted light. The wattage inputs of carbon arcs vary greatly Furthermore therapeutic results in man are not comparable to those in animals

Then practical difficulties in measuring the intensity of lights exist Most chemical tests which have been advocated aside from being complicated and impractical are sensitive to the many regions of the spectrum and even if this should not be the case the cutaneous response varies too greatly these variations even existing in the same patient after initial exposures

Variation in Response.—On the part of the patient great variation in response exists Thus blondes react differently from brunettes and the negro requires greater dosage than the white skin differs from mucous membrane and the child differs from the adult.

Variation in Effectiveness of Different Rays.—Lack of a fundamental understanding of light effects interferes with an interpretation

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Variation in Effectiveness of Different Rays.—Lack of a fundamental understanding of light effects interferes with an interpretation

of exactly what rays are effective, that is the ultraviolet as against the luminous or even the short ultraviolet as against the long ultra violet. (With clinical usage of sunlight in the lowlands of Connecticut where spectral determinations showed that the lowest ultraviolet limits used were 320 millimicrons many cases of bone and joint tuberculosis healed, and sinuses cleared up)

Physiologic Action.—Then the physiologic action of light is far from being clearly understood Are the effects mainly due to the production of a provitamin, or Vitamin D, or is light effective through changes in the skin, or by its action on the capillaries themselves? The absorption of electromagnetic energy by tissue cells produces many physical, chemical and biologic reactions—changes in tempera

FIG. 1.—Ameba feeding on infusorium cytolyzed by ultraviolet, showing space where absorption by pseudopod has occurred. This supports view that phagocytosis may be stimulated by ultraviolet. (C E. Barr in Journal Medical Research.)

ture, electrical charge and surface tension protein changes with variations in cellular coagulation and permeability and capillary flow alterations in the metabolism of the cells production of vitamin and bactericidal substances production or excitation of hormones and histamine-like substances as a result of intradermal stimulation polymorphonuclear leukocytosis nerve reflexes following the stimulation of end organs changes in inorganic salts of calcium and phosphorus production of erythema and pigmentation and finally what may be called the psychologic effects of treatment.

Value of Erythema or Pigment.—There is much difference of opinion as to the value of producing erythema or pigment It is questioned whether pigmentation is merely the response to ultraviolet and so acts as a protection against its overdose, or whether it has actual healing properties There are even those who claim that melanin is a hindrance because it makes necessary long exposures to light Can we get the same clinical effects by irradiating for shorter periods on less skin surface and by producing repeated mild erythemas instead of pigment? Most of this is yet to be settled.

Dosage

There has been a widespread impression that the greater the amount of ultraviolet given the better as long as excessive skin irradiation is avoided Yet numerous observers indicate that the effect is not proportional to the dosage and that an effect produced by smaller dosage may even be reversed when the larger dosage is given Thus small doses of ultraviolet lead to protein deposition while large doses destroy it. Small amounts of ultraviolet reduce consumption of frog muscle large amounts increase it. Short periods of exposure increase the complement activity of the serum calcium of guinea pigs prolonged dosage causes the disappearance of complement activity with death. Minimal ultraviolet stimulates the growth of fungi large doses inhibit it. Small doses of ultraviolet increase markedly the antibody values of rabbits blood large doses prevent this Irradiated cholesterol gives marked rise in antirachitic potency for a time, but a drop occurs with further irradiation.

Overdosage.—But fortunately overdosage with light applied clinically is not so dangerous as this would lead us to believe Happily nature reacts much more favorably to overdosage from light than to overdosage from x ray A margin of safety as great as 50 per cent exists and blistering itself has done little harm. Irradiated ergosterol given therapeutically to infants requires an excess of dosage four thousand times that of the minimal effective dose in order to produce illness and then generally when fever is present and the child shows anorexia and poor nutrition

However there have been isolated instances in which overdosage from light therapy has produced damage to patients when aged patients have had their resistance to infection lowered when overdosage in tuberculosis has produced focal reactions which were productive of damage the light setting up a focal reaction similar to that following tuberculin therapy The application of light in the treatment of acute infections has lessened resistance. The bactericidal power of the blood has experimentally fallen to a very low degree and in anemic animals where careful irradiation has led to regenera

tion of erythrocytes and hemoglobin, too vigorous exposures have destroyed blood cells

Overdosage even of 50 per cent may result in no harmful effects. If the dosage is underestimated the difference may be readily made up on the following day Dosage for desquamation by contact exposure with the better type of a new water-cooled lamp averages less than one minute. If quartz compression applicators about one inch thick are used desquamation time is raised somewhat, as there is a small space between the front window and the quartz applicators.

In view of the foregoing we may hope that when dosage and technic are put on a better basis even though standardization may be impossible, more uniform clinical results may be obtained or, at least, better comparisons may be made

Symptomatic Response.—Although it is impossible to offer fixed rules of exposures yet certain guiding factors may be borne in mind Since constitutional reactions can occur in patients symptomatic response together with cutaneous reactions will usually be the best guide for succeeding exposures. The production of slight favorable focal reactions is desirable if they can be controlled It must be remembered that certain patients may develop hypersensitiveness to light exposure. Under these circumstances one may have to withhold irradiation for a while or apply another source. Some peculiar skin reactions to ultraviolet rays have occurred Under prolonged exposure to mercury arcs the loss of pigmentation has resulted possibly where a stage of exhaustion of the basal epidermal cells has been reached.

Erythema.—Erythema has been used by many as a guide for dosage Is its presence necessary? Attempts have been made to correlate the production of erythema with an increase in the bactericidal power of the blood Although its development has been stressed in the treatment of rickets yet the band of rays about 280 millimicrons which is most antirachitic, is not erythema productive The erythema-producing region stands chiefly between 310 and 290 millimicrons (60 per cent between 302 and 297 millimicrons) and less intense around 250 millimicrons Yet without these rays exposures to the longer wavelengths (above 320 millimicrons) have produced healing in tuberculous bones and joints

With rickets and tetany more accurate dosage has now been worked out. The optimal dosage of ultraviolet, applied daily with a mercury arc in quartz to infants with tetany has been shown to be two minutes front and two minutes back at 50 cm. unless the burner is badly deteriorated and the minimal dosage necessary for cure is greater in negroes than in white infants With rickets five minute exposures both front and back at 80 cm., producing the faintest erythema at weekly intervals is curative Healing is brought about

in five to eleven weeks, which is practically the same time required by the heavier schedules used by most workers.

Frequency —Although frequency of exposures is another undetermined factor it is agreed that overdosage through too frequent irradiation has interfered with light action. In the prevention of colds workers have claimed that weekly dosages of only 10 minutes have been effective in cutting down the incidence in students as much as 40 per cent whereas larger dosages given more frequently have failed to accomplish this

Today the majority of workers give exposures every second or third day, or even less frequently in the treatment of most infections.

Coloring of Patient.—Blonde and auburn haired patients react more sensitively to light than do brunettes and so careful exposures are more necessary for them.

General Factors

Administration.—While patients should never be chilled during treatments it is generally advantageous to have sufficient ventilation and some air movement in the room but drafts about the source of light should be avoided

Heat rays in the form of heat therapy lamps may be used previous to the ultraviolet exposures if desired.

The eyes should be protected by snugly fitted goggles made of any glass except quartz and preferably colored brown to prevent a painful conjunctivitis The face may or may not be exposed

Condition of Burner —With the mercury arc in quartz the burner should be cleansed prior to lighting with a little pure alcohol or ether so that the dust will not settle in the burner and decrease its intensity and life

The lamp should be in operation for at least seven minutes before treatment is begun in order that it may reach its maximum intensity A lamp which can be operated at more than one intensity should not be operated at the highest intensity immediately after lighting as such a procedure will shorten its life.

The intensity of ultraviolet from a mercury arc lamp in quartz depends on the age of the burner the amperage and the voltage at which the lamp is operated and the temperature surrounding the burner

The process of aging may decrease the intensity of a burner to one half its original value The aging results from devitrification of the quartz walls the devitrification lowering the intensity by lowering the transmission

If a burner flashes but will not light, and the quartz walls have become discolored with a black smudge, air has leaked in usually because of a crack If so the burner should be returned to the manu facturer for repair or exchange

The best test for a vacuum is the fact that the burner lights with out discoloring the quartz walls The vacuum should not be tested by clicking the mercury in the burner, as this procedure frequently is the direct cause of fracture of the quartz Moreover clicking is not a test for a vacuum even burners that have considerable air can be made to click.

If a burner does not light readily the rods on which it rests should be examined to see whether they have sagged at the free end under the continuous weight of the burner thereby causing the burner to lie unevenly Careful bending upward of these rods will frequently convert a hard lighting burner into one which lights very easily

This procedure will also frequently remove annoying clicking sounds unless they are due to insufficient resistance in the electric circuit. The lamp operated on direct current will be ruined if the current is passed in the wrong direction as shown by the polarity indicator

Every effort should be made at all times to run lamps under the same conditions Variations in air currents and the temperature of the room and variations in the rate of flow and the temperature of the water employed in the water-cooled lamps influence greatly the radiant output.

Sunlight

For details of solar therapy see Vol. III (Rollier)

Mercury Arc in Quartz (Air-Cooled)

General Irradiation.—For most conditions employ general irradia tion in addition to local Acute progressive disease generally con traindicates irradiation especially when high fever exists. Chest exposures however even in tuberculosis are not contraindicated. No complicated technic is necessary for determining the intensity of the light used. A satisfactory guide is to expose four small circular skin areas on the forearm (anterior surface) for two three, four and five minutes at a distance of 75 cm and then to use the dose that gives the minimum erythema response This first exposure is usually for two or three minutes at 75 cm. with a new burner

This is the procedure with larger office models but with a home model of mercury arc in quartz which has much lower intensity larger initial exposures (five to seven minutes) are necessary With pronounced blondes and children one-half the initial dosage is em ployed

The writer induces the minimal erythema dose on small areas of the body so that the skin is kept in a mildly sensitive state during the whole period of treatment The application of the erythemal dose immunizes the irradiated area to reactions for three or four days this is due to the protective screening action of exudates in intradermal tissues During the stages prior to desquamation the skin is still immune to radiation since dead epidermal cells protect the skin from the ultraviolet rays During desquamation the exposed epidermal tissue is hypersensitive to light, and an irregular action results showing immune and hypersensitive areas For this reason a period of about ten days should elapse between the exposures of given areas of skin in order to keep the skin sensitive to ultraviolet rays for a long period Excessive heating of the body by prolonged exposure should be avoided

The author exposes about one fourth of the surface area of the body during the first treatment the chest and abdomen to the iliac crest are exposed with the lamp at a distance of 75 cm. (voltage of main supply 110 or 220 a c.)

The burner is first cleansed with alcohol the arc then burns for 7 minutes and finally the first exposure is made for two or three minutes at 75 cm with the burner centered over the lower edge of the sternum producing a faint redness within 24 to 48 hours after treatment The skin below the iliac crest is protected Exposures are made every other day to a different area of the skin The skin is never irradiated during the phase of desquamation

With the second exposure the burner is centered on the same level on the patient s back and the lower part of the body is covered

The third exposure is made with the burner centered over the middle of the thigh, the upper half of the body being covered

The fourth exposure is made over the middle of the thigh behind with the upper part of the back covered For these four irradiations the same period of exposure and focal distance are carried out

On the fifth exposure, one repeats the order prolonging the exposure one minute and repeating this on all four surfaces. This one-minute increase is repeated until an exposure of 10 minutes on all four parts is made when usually pigment formation occurs. Following this one may begin with a metal-cored carbon arc of 20 amperes or more, using the same faint erythema-production as a guide until the pigment formation is constant Then irradiations are discontinued until the skin again becomes light sensitive which is often three or four weeks Maximum exposure by this process generally reaches 15 minutes Constitutional reactions such as the elevation of temperature malaise anorexia, nervous irritability etc., and the production of focal symptoms as well as cutaneous reactions may serve as guides for successive irradiations

Local Irradiations.—By carefully controlling the dosage in local irradiation and thus avoiding excess damage to tissues, one can accelerate the healing of many types of septic wounds, overcome suppuration and necrosis lessen pain of ulcers, and destroy ulcers through necrosis and blistering However, general exposures are always applied with the local. Excessive local irradiation in subacute conditions will produce necrosis of tissue which may cause a spreading infiltrating cellulitis. In chronic fibrous lesions intense reaction may be required through massive dosage of light so that tissue is destroyed and fresh granulating surfaces are formed Mucous membranes are more sensitive to light than skin and so the dosage there must be more cautious.

For local treatment one should employ water-cooled mercury arc lamps or water-cooled carbon-arc lamps, either at short distance or by contact exposure or air-cooled lamps with distance exposures. Quartz rods in hollow tubes may be attached to water-cooled sources of lights for local application

The lesions should be first carefully cleansed all dead cells and scales removed and the surrounding area made clean (and occasionally bloodless by pressure to obtain better penetration of rays) Dosage must be carefully controlled Mild erythema dosage is desirable for clean granulating tissue Intense dosage is used for suppurating and necrotic areas. If applicators are used for ulcers actual contact with tissues should be avoided as this might produce an exudative film which would interfere with irradiation

Dosage.—The dosage varies. For chronic sinuses and ulcers and old standing foci of disease one should employ intense irradiation For fresh granulations one should employ a faint erythema dose exposures of from one to three minutes at one inch generally produce this with mercury or carbon arcs When local reaction disappears a succeeding exposure should be made usually in about a week. Quartz applicators should be used in small irregularly shaped cavities through them the intensity of the rays is greatly diminished the dose is varied depending upon the nature of the disease to be healed and the type of lamp employed.

Carbon Arc Lamp (Water-Cooled)

The water-cooled carbon arc lamp contains plain carbon electrodes for local exposures and rays emitted are of high intensity in the longer ultraviolet luminous and infra red Local treatment requires exposure as prolonged as one to two hours The claim made for the carbon arc lamp of deep penetration of tissue is obtained by this technic.

No formula for any of these exposures can be expressed because individual factors in reactions to local diseases vary too greatly but it is to be stressed that general exposures are always made in addition to local exposures if the latter are employed at all.

In carbon arc radiation general body exposures are also to be stressed With the carbon arcs of today we are dealing either with those that emit chiefly rays longer than 290 millimicrons namely lamps of the old Finsen type or the carbon flame lamps that emit strongly shorter ultraviolet rays down to at least 250 millimicrons. With the former the skin of the whole body is exposed from 20 minutes to 2 hours two or three times per week. The erythema is then produced by rays between 290 and 310 millimicrons and much of the beneficial action is due to the longer ultraviolet the luminous and the infra red rays With these arcs the skin becomes well pigmented Because of the therapeutic results achieved with carbon arc radiation the Danish workers are most enthusiastic for its use in tuberculosis

Finsen Carbon Arcs.—General Irradiation —At the Finsen Institute a room with a floor space of 5 5 by 7 meters and a ceiling 4 meters high is used for treatment with carbon arcs Its walls are painted dark blue The patient s face is protected with a paper shade and eye goggles are worn. The whole body is subjected nude to the radiation Two large carbon arc lights with no shade are suspended one and one-fourth meters above the floor The lamps have an amperage of 75 and a voltage of 50 to 55 the upper positive carbon being 31 mm. and the lower negative one 27 mm in diameter Only direct current is used. Six to eight ambulant patients seated in a circular area are treated at once under two arc lights The position of the patients is changed frequently so as to expose all parts of the body The light is as near to the body as the heat will permit, generally about three feet. The distance between the arcs of the two lamps is 60 cm The carbon electrodes are arranged in a vertical line the positive being placed above the negative so that the light will radiate downward With the direct current a crater is formed in the positive electrode and from this crater the greater part of the effective rays is radiated With the alternating current, on the other hand, the cone of light is emitted from the upper and the lower carbon-electrode alternately and therefore much of the effect of the chemical light is lost. Accordingly the alternating current should not be used without first being converted into direct current by a suitable rectifier No glass covering should be used around the light and the lamps must burn with a clear steady light Carbons should not emit soot. The large lamps generate a greater amount of chemical light than the small lamps, but this difference is neutralized by the fact that the patients cannot be seated as close to the large as to the smaller lamps because the latter give out less heat It is important that the patient be placed as close to the light of the small lamps as possible because the intensity of the light varies inversely as the square of the distance

For recumbent patients more seriously ill a system of arc lamps of 20 amperes and 55 volts each is used the upper carbon being 12 mm. the lower 8 mm. in diameter The system is connected either

in parallel or in series The lamps are suspended in a row and the patients recline on either side parallel with the lights, only two being accommodated at a time Here the focal distance is 50 cm The rays must fall obliquely on the body If the system is connected in series it is used only in connection with a current of 220 volts and a serial resistance of 55 volts The apparatus suspended from the ceiling has check rods in the perpendicular plane to prevent the lamps from having a rotary movement They must be capable of a vertical movement of one meter, so that in the end positions the distance of the light arc from the floor is 75 cm, but these measurements are subject to alteration according to the height of the patient's couch which must be as close to the lamp as possible The distance between the light arcs is 55 cm

At the beginning exposures are for 15 minutes soon increasing 20 minutes at every sitting up to two and one half hours every day or

FIG. 3.—Lupus of Face Fig. 1 resisting 30 months treatment with local carbon arc irradiation. Fig. 3 complete disappearance f disease after 6 months treatment with additional general body exposures t carbon arc. (Reyn.)

every other day The patients turn about every seven minutes the time being increased as they become more accustomed to the radiation. Water is drunk during the treatment. If perspiration is excessive, a bath, which may be slightly warm at first and cooled gradually is given afterward The room should be well ventilated

A latent period of 10 to 20 hours is followed by varying stages of dermatitis but pigment is soon produced. Often as many as 300 exposures are necessary to produce marked changes in tuberculosis

Those patients who have open wounds wear no dressings during the light bath. If the wounds secrete rapidly (the light bath often induces much exudation), the moisture is absorbed during the light exposures.

Local Irradiation.—Besides the general light bath the Finsen local treatment is used for superficial wounds and fistulas in the same way as for lupus The light from an arc lamp of 50 amperes is concentrated through an apparatus with convergent lenses which must be made of quartz and not of glass. This local treatment is of great importance with superficial soft wounds and fistulas which as experience at the institute has shown, are in many cases the beginning of cutaneous tuberculosis and lupus

Even if light baths are in many cases used as the sole treatment for surgical" tuberculosis the old recognized conservative surgical and orthopedic methods of treatment are by no means discarded. Abscesses which will not disappear are punctured and injected with iodoform-glycerin Superficial abscesses which do not disappear when punctured are incised the soft parts are scraped out with a sharp curette and treated with phenol but the bones are touched only with great caution unless they have already been scraped out before the patient comes under treatment. Deep-lying cold abscesses originating from spondylitis pelvic osteitis or coxitis are not incised. For these only puncture and iodoform injections are used Sterile dressings are carefully employed but this is naturally difficult with the ambulant patients

Wounds and fistulas are almost always treated by cauterization every second day with a 33 per cent solution of silver nitrate applied with sterile pads of cotton wool This cauterization seems to be valuable in tuberculous wounds whether originating in a bone affection or a tuberculous lymphoma

Bandaging of the diseased joint is not done, except to alleviate pain and prevent deformities Removable plaster bandages which can be taken off during the light bath, are preferred In tuberculosis of the knee joint bandages are desirable because in some cases which were treated without them flexion contraction and later subluxation resulted For bandaging the knee circular plaster of paris is used

Arrangement of Room.—In each light-bath room is a control board with fuses and switches An ammeter is mounted for each 75 ampere lamp and a common voltmeter with a change-over switch and adjustable rheostat is part of the equipment For 20-ampere lamps a common voltmeter with a change-over switch and fixed rheostat is mounted

The front of the board with the operating handles and instruments faces the light-bath room while the back with the rheostats fuses and connections faces another easily accessible room When such an

arrangement cannot be had, the control board should be mounted on an iron frame and placed at a distance from the wall that permits repairs to be carried out on the rear of the board

All conductors between the converter (or supply) and the lamps should have a section area of not less than 35 m. for 75 ampere lamps and of 16 m. for 20-ampere lamps

When arranging a light bath room, the following directions should be observed as far as possible

The room should be of such size as to prevent the heat from the burning lamps from becoming too disagreeable A cubic content of 90 to 100 m is suitable for a room with two 75-ampere lamps, while a cubic content of 75 to 80 m is sufficient for a room with three 20-ampere lamps.

Experience has shown that the floor space of a light bath room should preferably have the following dimensions

For 2 75 ampere lamps	5 0 by 4.8 m
For 3 20-ampere lamps	5 5 by 3 5 m.
For 6 20-ampere lamps	5 5 by 5 5 m.

The height of the room should preferably be not less than 4 meters. The ventilation will be most effective if the windows are placed in the opposite walls just below the ceiling, and so arranged that they can be opened and shut from below Thus unsteady burning of the lamps is avoided. It has been proved that almost any other form of ventilation will exert an unfavorable influence on the arcs, owing to the movement of the air immediately surrounding the lamps

It should be possible to heat the rooms prior to the lighting of the lamps, but the heat from the lighted lamps will be more than sufficient so that it will be necessary to reduce the heat. A central heating system will thus be most adequate.

It is advantageous to have a shower bath with hot and cold running water and a lavatory adjacent to the light-bath room

A detailed description of these arcs is presented because many light institutes abroad have installed them according to the advice of the Scandinavian workers. However it has been found by engineers here that arcs equally if not more efficient clinically can be constructed which do not conform with the exact principles of the Danish arcs

American Carbon Arcs.—Many carbon arc sources are available in this country They vary greatly in individual construction

The total emission of radiation and the relative intensity of their spectral components may be altered by varying the voltage and amperage, altering the diameter of the carbons, and impregnating the carbons with suitable metals or salts The high intensity arc has an output of total energy which is close to that of sunlight. Nickel iron titanium aluminum and tungsten are all employed for impregnating the carbons.

Arcs using 45 to 90 amperes can irradiate as many as 20 patients at a time The cost of installation the operating charges of large carbon arcs and the care necessary make them useful chiefly for the handling of groups of subjects in institutions

There are some workers who have even enclosed their carbon arcs with special glasses to filter out the radiation below the lower limit of the solar spectrum, and aim to imitate sunlight not only in its limits and intensity but in the relative proportions of the various regions so as to employ long exposures and obtain similar production of pigment.

The greater the amperage in these arcs the more heat is generated A lower amperage arc therefore can be operated nearer to the patient because of the lessened heat. Close exposures increase the quantity of light utilized As a result lesser amperage arcs such as 29 amperes with specially impregnated carbons may prove as effective on close irradiation of single patients as high amperage arcs necessitating operation at greater distances and for general employment of groups

Installation —Two 60-ampere carbon arc lamps are permanently fixed in the center of the ceiling of a room approximately 18 feet by 21 feet, 5 inches The arc height is 6 feet 9 inches and the voltage across the arc is 50 volts 60-cycle alternating current. The upper carbons are 22 mm (7/8 inch) in diameter and the lower 13 mm. Both are copper coated to carry this amperage These are fed automatically by a motor through reduction gearing which maintains a constant emission of light continuously during the course of treatment A sensitive switch solenoid arrangement in the arc circuit maintains 60 amperes across the arc at all times. These lamps can be used for group irradiation Where the patients have had no previous treatment one starts by giving the irradiation one minute anterior and one minute posterior at approximately a six foot distance gradually increasing the time to ten or fifteen minutes depending on the patient s reaction or toleration for light

Another lamp of the ceiling suspension type is such that each of the four 60-ampere units making up the multiple unit is entirely screened with special glass filters These screens filter out practically all energy in wavelengths shorter than 2 900 A not present in solar radiation

Each individual 60-ampere unit (240 amperes total) has a definitely maintained arc amperage of 60 amperes This is kept up by a specially wound motor Thus the intensity of light is constant within the close limits of plus or minus one per cent. At a distance of 5 feet 6 inches below the center line of the arc and 4 feet out from the center line of the unit, the energy distribution between 2 900 and 3 100 A is 99 per cent of clinical sunshine At a distance of eight feet from the center line of the unit measured in the same horizontal plane the energy in this band is 105 per cent of clinical sunshine. To obtain

increased strength of radiation in wavelengths shorter than 3,200 A° and down to 2,200 A°, different carbons are used and the special glass screens are removed This is an automatic unit, operating for ten hours without adjustment.

As to mercury-quartz solaria There are various installations, such as those equipped with ceiling suspensions or vertical stands and those with wall lamps and vertical reflectors. The latter are designed to be built in flush in a tiled wall They are equipped with cylindrical chromium lined reflectors, and installed at a height of about four feet from the floor The ceiling suspension lamps are eight feet from the floor to the lower rim of the reflector the wall type lamps are three feet, six inches from the floor to the lower edge of the wall recesses

The aim is to obtain an even intensity of illumination. This is achieved by placing patients inside a marked line that runs along the floor around the room.

Indications for Use.—It is not yet possible to express emphatically the indications or even the contraindications for these arcs When sunlight is uncertain all these artificial sources are valuable aids and substitutes In using the carbon flame lamps, I aim for the production of a faint erythema on skin areas equal to about one-fourth the surface of the body maintaining skin sensitiveness by irradiating a new area every other day If pigmentation forms I discontinue exposures until skin sensitiveness returns

Other artificial sources of light are employed by workers partic ularly those abroad but I have not found them superior to the arcs mentioned.

All the sources of light, although valuable aids for certain con ditions must yet be understood to be only adjuvants and sole reliance for therapy should not be placed in them. Other means of treatment at one's disposal should not be discarded

Combined Use of Ultraviolet and X Rays

Although formerly there was a difference of opinion as to the ad vantages or disadvantages of the combined use of ultraviolet and x rays today much of this doubt is dispelled Ultraviolet, regardless of how it is used is not a prophylactic against acute or chronic x ray dermatitis Sequelae such as telangiectasia are more likely to be followed by the combined use of ultraviolet and x ray than when x ray alone is employed. General exposures to ultraviolet, even when con tinued for a long time, do not decrease sensitiveness to x ray A vig orous actinotherapy which results in acute reactions at or near the time when x ray exposures are to be made may enhance the result of the latter Tanning of the skin by ultraviolet does not increase toleration for x rays

The age or thickness of the horny layer of the skin or the size of the area treated may all be factors that affect the erythema response to x rays so that even four times the standard erythema dose may be applied without provoking more than a moderately intense visible reaction. Visible reactions are poor guides to x ray therapy as they do not indicate intensity or depth of biologic reaction. Variations in output of different Coolidge tubes may even reach 80 per cent. An experimental error of 100 per cent may be detected only with difficulty by skin effects therefore it is unwise to depend on the supposed prophylactic action of ultraviolet against x ray treatment until irrefutable proof is presented.

CHAPTER FOUR

TREATMENT OF SKIN DISEASES WITH RADIATION

GEORGE M MACKEE, M.D., AND ANTHONY C CIPOLLARO M.D

INTRODUCTION

Radiation of various kinds has been used for the treatment of dis eases of the skin for a great many years. Sunlight (heliotherapy) is a very old therapeutic agent While it has been replaced to some extent by artificially produced radiation it is still used Radiant heat is employed occasionally but this together with heat by conduction and convection has been displaced to a large extent in recent years by heat by conversion particularly medical diathermy (high frequency current) The x rays are the most useful and popular type of radia tion used in dermatology Radium also valuable and popular is given second place

Those who read the three chapters in these volumes which deal with dermatology (Vols I and II and this chapter) will appreciate the fact that the various physical therapeutic agents are used extensively in dermatology In fact, the authors are afraid that the reader may be led to place too much importance on physical therapy There are many physicians who obtain a little knowledge of dermatology who equip their offices with physical therapy apparatus and who make good livelihoods Such conduct is inimical to the future of derma tology medicine and humanity Physical therapy is invaluable to the dermatologist. Not infrequently the application of some form of physical therapy particularly the x rays offers the sole means of affording relief from suffering but very often the relief is temporary unless the cause is ascertained and overcome Those physicians who take the path of least resistance by depending largely on physical therapy are woefully lacking in therapeutic resourcefulness They try one physical therapy agent after another together with various topical remedies and when these fail as so often happens they are hopelessly perplexed Such physicians guess at the diagnosis they treat diseases with physical agents when such agents are contraindicated or when conventional dermatological management would produce much better results and they report good results in diseases that clear up spon taneously in the same length of time

Fifty or more years ago all dermatologists were externists That is, it was thought that most of the dermatoses were due to external

causes that the skin was largely independent of the rest of the body and that skin diseases required, for the most part, only local treat ment. It is now realized that the skin is one organ of the body as intimately related to the whole economy as is any other organ The modern dermatologist is an internist. Real success in the management of diseases of the skin requires an excellent knowledge of the basic medical sciences a broad experience in general medicine and surgery, and a thorough training in the specialty of dermatology With such a background one knows when to be an internist and when to be an externist that is a qualified dermatologist knows usually when an eruption is due to internal causes external causes, or a combination of both Diagnoses are made with reasonable accuracy, causes are ascertained when it is possible to do so and the treatment that is most suitable for the particular case is instituted

X rays and radium are too dangerous to be used therapeutically ex cept by those who have received adequate training The other physical agents (diathermy refrigeration electrolysis ultraviolet radiation) so often employed in the treatment of skin diseases are not nearly so dangerous and may be used by the general physician However, a physician who desires to use these remedial agents should be willing to spend time and money for the acquisition of necessary knowledge. These comparatively safe remedial agents are capable of producing very undesirable results when employed carelessly injudiciously or unskillfully or when contraindicated The physician should not obtain his information from the manufacturer If possible he should take a postgraduate course in a medical school When this is impossible, he should read reliable medical works and attend lectures given under the auspices of altruistic medical bodies A physician who is unwilling to do at least this much is not to be trusted with physical therapeutic agents not even with ultraviolet radiation So far as concerns the treatment of skin diseases the physician who has no knowledge of dermatology is handicapped by inability to establish diagnosis For this and other reasons all sorts of skin conditions are treated with ultraviolet radiation when such treatment will accomplish no benefit, when it may do harm, or when other remedies would effect a prompt cure This kind of criticism irritates the physician who is not a derma tologist. He should understand however that the criticism is not for the purpose of discouraging his use of physical therapy or to dis- courage him from attempting to treat skin conditions In fact, the family physician should be encouraged to treat these diseases and the patient should be encouraged to consult the family physician before going to a specialist The commentary is for the purpose of urging the general physician to obtain knowledge and training in the use of the comparatively safe physical agents and a knowledge of the com mon skin diseases and not to attempt the treatment of a disease with a physical agent when his common sense warns him that he should not do so

This chapter is for physicians other than dermatologists In it an attempt is made to give the indications contraindications technic, etc. of radiation for the treatment of skin diseases in a manner that will be of practical value Because the practitioner of general medicine does not employ x rays and radium, very little will be devoted to apparatus and technic But the general physician should know what can be accomplished with x rays and radium treatment. For this reason the chapter includes indications comparisons with other forms of treatment dangers and other features about which every physician should have some knowledge

SECTION ONE ROENTGEN RAYS*

X rays constitute the most valuable single remedy in dermatology Eighty or more diseases and conditions are amenable in some degree to this agent. In the hands of one who is skilled in their use one who is cautious and capable of good judgment they are safe otherwise they are exceedingly dangerous In dermatological practice they are used largely as an adjuvant, although for some diseases they are the only remedy that will cure or give relief while in others they are often preferable to other therapeutic methods

Physics

As the physics of x rays is given in another chapter of these volumes it is advisable to give here just enough to serve as a preface for what follows

X rays are oscillating particles of energy They obey many of the laws of matter and the laws of vibrations. It is customary to speak of them as electromagnetic vibrations or waves The primary beam of x rays is heterogeneous that is it is composed of waves of various wavelengths The wavelengths are shorter than those of ultraviolet radiation and those in ordinary use are longer than filtered gamma rays X rays follow the very short ultraviolet rays in the invisible spectrum Recently x rays generated by a million volts have been produced *These have exceedingly short wavelengths and do not concern us* X rays travel at the speed of light.

The wavelength of x rays depends on voltage and ignoring for a moment the density of the substance through which the rays pass penetrability depends upon the wavelength The shorter the wave length, the greater is the penetration Absorption depends upon wave length and upon the density and thickness of the material through which the radiation must pass also naturally upon intensity and time of exposure The heterogeneous primary beam even with high voltage contains a great variety of wavelengths and each wavelength has its own rate of absorption but the rate is less for short than for long

* Considerable material used in this Section is taken from the senior author's book X Ray and Radium in the Treatment of Diseases of the Skin, Ed. 3 1938, Lea and Febiger Philadelphia.

waves Assuming the body to be composed of layers of tissue, each layer being of like density and thickness, and disregarding the effect of scattering and distance absorption will be approximately exponential, that is, the first layer will absorb a certain fraction of the primary beam, the second layer will absorb the same fraction of what its proximal surface receives, and this will be true for each layer in succession But as mentioned above this rate of absorption differs with each wavelength The longer the wavelength, the more the first layers absorb and the greater the difference between that absorbed by the first layer and that by the second layer As biologic and therapeutic effects are the result of absorption (loss of primary beam), it is customary to employ a primary beam that contains a maximum of wavelengths most suitable for the purpose for which they are to be used This is accomplished by varying the voltage and by employing a filter The higher the voltage, the shorter are the wavelengths. For the routine treatment of skin diseases it is customary to use from 60 to 100 kilovolts for diseases of the deeper parts of the body, from about 150 to 300 or more kilovolts Filters are used to absorb the longer wavelengths With heavy filtration and very high voltage the resulting beam contains only short wavelengths but it is never entirely homogeneous In dermatological practice it is customary to use unfiltered radiation for very superficial affections and light filtration (one-fourth to three millimeters aluminum) for thick lesions and lesions involving the subcutaneous tissue

Production of X Rays.—X rays are produced by the passage of a high tension (high voltage) current through a specially constructed vacuum tube (x ray tube)

Modern tubes are of the hot-cathode type having an almost complete vacuum. The cathode or negative pole consists of a spiral filament of tungsten wire which is heated by means of a low tension current. This hot cathode provides free electrons which because of a focusing device and the high-tension current, travel from cathode to anode (target) at tremendous velocity They are stopped suddenly by the target. The sudden arrest of a high velocity electron gives rise to electromagnetic vibrations which are x-rays The wavelengths of the x rays depend partly on the suddenness with which the electron is stopped but in practical work this factor may be ignored because it is a fixed factor and depends on the construction of the tube The velocity of the electrons (cathode stream cathode rays) depends entirely upon the voltage of the high tension current. The higher the velocity the shorter are the wavelengths of the x rays It may be said then that wavelength (quality) is governed by voltage The number of electrons depends upon the amount of heat in the cathode (ignoring construction of cathode) which in turn is governed by the amperage in the low-tension filament circuit The larger the number of electrons the lower is the resistance in the high tension current. Current passes

more easily and unless more power is supplied there will be lessened electron velocity with decrease of x ray quality and increase of quantity It may be said then that quality (wavelength) depends upon voltage and quantity or intensity depends upon milliamperage in the secondary or high tension current. These factors are governed by controlling amperage and voltage in the cathode filament circuit and in the primary circuit of the high tension transformer

The cathode rays being composed of electrons can be likened to the beta rays of radium. Their penetrability depends on their velocity and under ordinary conditions they cannot penetrate the glass wall of an x ray tube With specially constructed tubes and very high voltage it is possible to obtain these rays in abundance Roughly their biologic and therapeutic properties are those of beta rays of radium. However thus far they have been used only experimentally in laboratories.

SECONDARY SCATTERED CHARACTERISTIC AND CORPUSCULAR RAYS —*Secondary Radiation* —Secondary radiations are emitted by substances traversed by a primary beam of x rays There are three types of secondary rays. They are scattered rays characteristic rays and corpuscular rays

Scattered Rays may be considered as primary x-rays which have become deviated. X rays are scattered (deviated) in all directions by any kind of matter through which they pass The greater the mass encountered the greater is the scattering Scattered radiation is softer than the primary beam due to gradual degradation of the energy Scattered radiation has to be taken into account in figuring out dosage because it may amount to as much as 42 per cent of the primary beam for a large field

Characteristic Rays When a primary x ray beam (photon) collides with an electron in a K L or M shell of an atom in such a way that all or part of the energy is given over to the electron characteristic rays are produced The shells are quickly filled with other electrons from neighboring atoms and energy is then liberated in the form of radiations of sharply defined (homogeneous) wavelengths This constitutes the characteristic secondary radiation The hardness of these rays depends upon the material in which they are produced Thus characteristic radiations produced in copper are much harder than those produced in aluminum and in either case they are softer than the original x ray beam In practical work auxiliary filters of lower atomic weight are used to absorb characteristic radiations given off by filters of high atomic number

Corpuscular Rays These are really emitted electrons from matter traversed by a primary beam of x rays The electrons of high velocity are called primary photo electrons The electrons of low velocity which are more numerous are called recoil electrons All the corpuscular rays are easily absorbed by a few centimeters of air They are responsible for the ionization of air

It is probable that the biologic and therapeutic effects of x-rays are due to ionization—breaking down of the atom—and it is possible that most of this ionization is due, not to the primary radiation, but to the beta rays caused by them

Attempts have been made to use secondary rays therapeutically, but without much success Secondary rays are produced when the primary beam of x rays passes through some metals used as filters—copper, silver, etc Such radiation, for the most part lacking in penetrability is absorbed by the skin and may injure it. For this reason it is customary to have the filter some distance from the skin Aluminum is an exception. It seems to cause few if any secondary rays For this reason aluminum is used as a filter by dermatologists Because of its low atomic weight it has to be quite thick. Those who use extremely high voltage usually employ copper or some other heavy metal, such metal being lined with aluminum which absorbs the secondary rays from the heavy metals.

Apparatus

Transformers.—A detailed description of x ray apparatus is given in another part of these volumes. The conventional type of x ray machine is used in dermatology Briefly this consists essentially of a step-up transformer to produce the necessary high tension current a rectifier to convert the high tension alternating current into a pulsating unidirectional current an autotransformer or rheostat, usually the former with which to control the primary current a voltmeter and ammeter in the primary circuit and two milliamperemeters in the secondary circuit also a small step-down transformer with controls and meters for current with which to heat the cathode filament. The apparatus functions only with alternating current. If the commercial current is direct it is converted into alternating current by means of a rotary converter

Apparatus suitable for dermatological practice provides a maximum of about 120 kilovolts although some dermatologists prefer machines that will give 140 kilovolts. The minimum is usually between 40 and 60 kilovolts

It is unusual to use over five milliamperes of current, but the apparatus will supply heavy current if desired. The apparatus is housed in a cabinet which need not be more than a few feet high, wide and deep It is however too heavy to be portable The controls and meters are mounted on the cabinet If so desired for economy of space, the transformer and vacuum tube rectifier may be mounted on the wall under which may be placed the treatment table. The meters and controls may be mounted on the opposite side of the room behind a lead-lined protection screen. In this way the physician can control the current, watch the patient and remain behind the screen, all in a small room. The protection screen is seven feet high, extends entirely to the

floor and is four feet wide It is covered with heavy lead and contains a window of heavy lead glass

X Ray Tubes.—The x ray tube is the standard Coolidge type This is housed permanently in a box which is lined with either heavy lead glass lead or lead rubber combination The undersurface of the box contains an adjustable opening through which the radiation may pass and into which a filter may be inserted The box is mounted on a tube stand which may be adjusted to almost any conceivable position and angle and which in turn, is mounted either on the wall or on the treatment table

Apparatus equipped with thermionic rectifiers do not as a rule contain a spark gap because sparks jumping across the gap may puncture the expensive rectifying tubes

Portable X Ray Apparatus.—The portable type of x ray apparatus manufactured by many concerns eventually may prove adequate for routine x ray work in dermatology Such apparatus consists of a small transformer autotransformer rectifying tube and small radiator type Coolidge tube all housed in a metal tank filled with oil The tank contains a thin aluminum 'window' through which the rays may pass It may be mounted on the wall by means of an adjustable bracket The apparatus is designed for about 50 or 60 kilovolts and from 1 to 10 milliamperes. With low milliamperage this apparatus will run for hours without overheating It has been used a great deal for diagnostic purposes but has not yet been tested thoroughly for therapeutic work.

Aerial High-Tension System.—It is customary in dermatological practice to use the conventional aerial system of copper tubing for the high tension circuit. The tubes are coated with chromium or nickel which is easy to keep clean Attached to the tubing are reels containing insulated flexible copper wire conducting cords that connect the aerial system to the terminals of the x ray tube Modern apparatus is constructed with an insulated aerial high tension system so that the equipment is completely shockproof

Biologic Physiologic and Chemical Aspects

For our purposes a description of the basic biologic features may be brief with a little more attention devoted to those biologic aspects that appear to have a special bearing upon normal and abnormal skin and the treatment of skin diseases

Chemical Action—X rays are able to effect alterations in elementary substances and in simple and complex organic compounds The chemical action is one of oxidation but the actual physical process is atomic as well as molecular and is apparently brought about through the process of ionization Silver bromide is reduced to metallic silver

(photographic action), platinocyanide of barium is changed from the crystalline to the amorphous state (dehydration) with consequent change in color iodoform in chloroform undergoes a color change and free iodine is liberated These and other chemical changes have been used extensively in the past for estimating x ray intensity (photographic radiometers dosimeters that depended on a change in color of pastilles coated with platinocyanide of barium, etc.)

Biologic Action.—A number of investigators have shown that x rays possess the property of modifying the production and action of enzymes and ferments contained in individual cells The findings of various workers are not in accord but the opinion seems to prevail that very small doses accelerate and large doses inhibit the production and action of these substances In the laboratory it is possible to kill microscopic organisms in culture especially with beta rays of radium Inasmuch as beta rays (corpuscular secondary rays) are produced in the tissue during the passage of x rays and gamma rays it was thought that the "bactericidal" action of x rays might prove of value therapeutically This bactericidal action has been used with some success commercially, but therapeutically it appears to be of little, if any importance.

Embryonic Cells.—X rays exert a profound influence on many developing forms of animal and plant life (embryonic action) Extensive work has been done on the ova and larvae of fish, birds, insects and mammals The result depends upon the dose and the stage of development. Broadly a cell undergoing division or about to do so is very easily modified During the rest state a comparatively large dose is required A minute dose accelerates, while large doses retard or inhibit, cell division Acceleration is temporary and as will be seen later, it is the retarding or inhibiting effect that is of importance therapeutically It has been known for many years that immature cells cells in an active stage of division and physiologically active cells are more 'radiosensitive than are cells that are comparatively physiologically inactive or cells that have acquired their fixed adult morphologic and physiologic characteristics For these reasons x rays will sterilize both male and female abortions can be effected in the early stage of pregnancy the sweat glands and hair follicles are more readily influenced than are other portions of the skin and so on.

Biologic Explanation of Effect of X Rays.—Numerous attempts have been made to explain the phenomena subsequent to irradiation of normal and pathologic tissue The microscope shows many of the histologic phenomena (cytology) but the morphologic picture fails to explain the fundamental changes The physiologic chemist has demonstrated important biochemical alterations and the physicist has shown us that most of these changes are atomic—a process of ioniza

tion Ionization and biologic effect run parallel. What takes place in the cell how, and why? A number of hypotheses have been advanced in answer to these questions The lecithin hypothesis chromatin hypothesis enzymatic hypothesis and the point heat hypothesis have never been received with favor The effects of the roentgen rays on living cells and tissues may be summarized somewhat as follows (taken mostly from an article by Loeb)

Intrinsic sources of radiation are produced within the body—secondary rays and scattered rays

Degree of sensitiveness of living matter to radiation Actively dividing cells young cells and physiologically active cells are more sensitive than are resting cells mature cells and cells that are comparatively inactive physiologically

The radiation affects cytoplasm and nucleus

Action of the radiation is directly proportional to intensity

Graded effects of the radiation on growth are not peculiar to the action of x rays or alpha beta and gamma rays but are similar to the effect of heat on cells

A latent period separates the time of application of the rays and the appearance of manifest consequences The duration of this period varies inversely with the intensity of the radiation It may be absent when the dose is very great

Effects of various kinds of rays do not differ in a way corresponding with their physical differences

Clinical Effect of Roentgen Rays on Animal Organs and Tissues

Inasmuch as this phase of the subject is given at length in other chapters it will suffice here to emphasize features that are especially important in dermatology

Ovaries and Testes.—The ovaries and testes are very susceptible to x rays The ovaries are fairly well protected by distance and thick abdominal tissue therefore they are unlikely to be injured with the amount of x rays that is given customarily for the treatment of skin diseases In certain affections however which may receive intermittent treatment over a period of years especially with filtered rays it is wise to protect the ovaries The testes are covered with comparatively thin tissue and unless well protected are likely to be injured

Hematopoietic System.—The effect of x rays on the hematopoietic system is marked particularly the lymphocytes and lymphoid tissue This fact as has been remarked by several authors but especially by Desjardins is of great importance biologically and therapeutically All lymphoid tissue is very sensitive to x rays being in susceptibility next to the ovaries and testes therefore diseases such as the lymphoblastomas yield well to irradiation.

Endothelial Cells.—The endothelial cells are no more sensitive to radiation than are the epithelial cells of the epidermis, but they are injured by large doses. Injuries to the cutaneous blood vessels and supporting structures lead to telangiectasia and other permanent sequelae

Action of X Rays on Pathologic Tissue

To some extent we have already discussed the cytologic, biochemical, physical and bacteriologic action of x rays It now remains to apply this knowledge, hypothetically and speculatively, in an attempt to explain the action of the rays on skin diseases The principal facts to keep in mind are that undifferentiated immature biologically and physiologically active cells, and cells in the stage of division, are most readily influenced that every type of cell has a specific sensitiveness, some being comparatively resistant while others are comparatively sensitive, but that all have some degree of sensitiveness, also, that the lymphocyte is especially sensitive.

Stimulation.—In the past considerable attention has been given to the so-called stimulating action of x rays and it has been thought by many that stimulation was the cause of benefit in many diseases also that stimulation when contraindicated would make a disease worse and would even cause cancer While it is true that it is possible to stimulate (in the sense of acceleration) animal and plant life with very minute doses of x rays it is doubtful if stimulation plays a role in any therapeutic result, good bad or indifferent. Clinicians speak of the stimulating action on disease and of stimulating treatment. This belief has taken hold because it is easily visualized, because of acceleration of cells in the laboratory, and because of the beneficial action of small amounts of radiation on affections such as eczema psoriasis, and particularly mycosis fungoides. These diseases however are associated with considerable cellular activity—acanthosis infiltration—features which one might expect to be increased by stimulation but which are inhibited by small doses on account of the susceptibility of biologically active cells Furthermore these affections and, in fact, most of the cutaneous diseases that yield readily to small amounts are associated with considerable congestion or hyperemia. This means an increased local iron content which when acted on by x rays, emits secondary radiations in larger amounts than would otherwise occur The principal infiltrating cell in these affections is the lymphocyte and all lymphoid tissue is so susceptible that small doses exert an inhibitory action

The stimulating effect of roentgenization has been blamed for poor results in cancer The consensus of expert opinion is that poor results are due not to stimulation but to incomplete inhibition caused in various ways—faulty technic resistant type of cell etc. It has been claimed that stimulating doses of x-rays have caused epithelioma on

lupus vulgaris and lupus erythematosus With the exception of cancer as a result of chronic radiodermatitis cancer in lupus erythematosus and lupus vulgaris is no more frequent today than before the advent of the x ray in other words, epithelioma when occurring in these diseases may be the result of the disease the result of chronic radiodermatitis or both In this connection it has been stated repeatedly that the stimulating action of small doses of x rays causes cancer There is no scientific evidence to substantiate such a statement There is plenty of evidence to support the opposite contention namely that because of excessive inhibition tissue is injured beyond repair (chronic radiodermatitis) which condition is placed among the so-called precancerous dermatoses

Hypertrichosis following x ray treatment of acne vulgaris has been noted the growth of hair being due it was thought, to the stimulating effect of the rays on the hair follicle and hair bulb Those who believe in this possibility will admit undoubtedly that hypertrichosis does not follow x ray treatment of other diseases that require the same technic. Furthermore superfluous hair is often seen subsequent to acne vulgaris which has not received x ray treatment and which may be due to long-continued hyperemia of the follicles caused by the disease or topical treatment or there may be an endocrine dysfunction In any event there is no corroborated evidence to prove that x rays are capable of increasing the growth of hair After depilation in tinea tonsurans it happens occasionally that the hair is greater in amount than before the treatment the reverse is also true It has been averred by such able roentgenologists as Bordet Holzknecht, and Kienböck that small and even large doses of x rays are beneficial in cases of alopecia of various types The authors have not been able to confirm these observations Occasionally acne vulgaris when under fractional x-ray treatment, will get worse during the first few weeks and psoriasis eczema lichen planus and other affections may get worse instead of better but this may be a biochemical reaction unrelated to stimulation The Arndt Schulz law (stimulation) is no longer considered an important factor The consensus of opinion at the present writing seems to be that inhibition is the important factor

Accumulation —The effect of repeated doses is cumulative and accumulation results in inhibition The degree of accumulation depends upon the size of the dose and the length of the intervals between treatments Kingery has placed the question on scientific grounds His work assumes a hypothetic decomposition product in the tissues as a result of irradiation By a large series of titration experiments he found that this hypothetic substance obeys a well known law of biology and chemistry—the law of mass reactions After a so-called saturation dose the rate of reduction of the irradiation effect (hypothetic substance) follows a definite law The velocity of reduction varies directly with the degree of concentration. The greater the concentration the higher

is the velocity of loss. As concentration decreases, the velocity of loss becomes less in direct ratio When concentration has been reduced to one-half the velocity of loss has been reduced to one-half, etc. After a so-called concentration or saturation dose (suberythema dose), half value is reached in three and a half days, while the effect is not entirely lost for three weeks In order to maintain saturation, it is necessary to administer one-half saturation dose every three and a half days or one-quarter saturation dose about every one and a half days. This so-called saturation method has been slightly modified and used by Pfahler and others especially for the treatment of cancer The technic of Coutard involves the application of a portion of the whole dose at a time until a certain tissue reaction is obtained Because of the danger of permanent injury to important parts, it is used only by those who are exceptionally expert.

PARASITIC DISEASES

The occasional quick response to roentgenization of bacterial affections such as sycosis vulgaris, acne vulgaris and acne varioliformis has suggested the possibility of a direct or indirect effect on the causative micro-organisms. As mentioned above, it is probable that in practical work there is no direct effect on micro-organisms either by the primary beam of x rays or by the secondary rays There may however, be an indirect effect through the ability of radiation to modify the soil. This modification may be caused by the destruction of lymphocytes and consequent production of antibodies (Desjardins' theory) alone or combined with other inhibiting effects As is well known, the lymphocyte is an important immunologic factor At one time it was thought that resistance to cancer parasitic diseases and other affections might be increased by irradiating the spleen and other organs with very small doses of x rays thus increasing the number of available lymphocytes. In practical work this has failed It was assumed that the local destruction of large numbers of lymphocytes might prove injurious a theory that has failed to receive clinical corroboration. Desjardins has advanced the interesting and plausible theory that an important function of the x rays in certain diseases is the local destruction of lymphocytes with consequent liberation of immune bodies or antibodies Most of the bacterial diseases that are readily amenable to x-rays are follicular in type and a possible explanation for their efficacy may be the fact that the cutaneous appendages particularly the hair follicles are extremely susceptible to irradiation. Most of these diseases (boils, acne vulgaris acne varioliformis) are not only follicular but they are caused by the staphylococcus and are associated with a dense lymphocytic infiltration Many of the streptococcic affections, while being follicular have less lymphocytic infiltration and, as a rule they are more stubborn than are the staphylococcic affections There are, of course exceptions Erysipelas or instance, seems to yield

well to properly applied x rays Cutaneous tuberculosis yields very slowly and recurrences are common The cutaneous lesions of syphilis and leprosy may improve under roentgenization but not to a useful degree The common wart and the plantar wart undoubtedly of virus etiology often undergo involution as a result of a single erythema dose. Conversely the flat juvenile wart and other warts also of virus etiology are recalcitrant. Parasitic eczema is often more stubborn than other forms of eczema. It is well known that incomplete epilation will often suffice to cure tinea tonsurans This might be accepted as indicating a parasiticidal action, but a more reasonable interpretation is that the affected hairs depilate more readily than do the healthy hairs This same phenomenon is noted whenever the scalp is congested (as in psoriasis eczema, etc.) Increased blood supply probably through increased iron content causes more secondary rays Conversely skin that is poorly supplied with blood is less sensitive To conclude this particular phase of the subject it suffices to say that there is no experimental proof and very little clinical evidence in support of the sterilization theory as applied to micro-organisms It is possible that in some instances irradiation by inhibition might increase resistance against invading organisms through some biochemical alteration or it may destroy an abnormal reactive factor instead of the etiologic factor and the host in the meantime develops local and perhaps general resistance.

Inhibition.—In the light of present knowledge the therapeutic action of x rays can be best explained by an inhibitory action in karyokinesis on young cells and cells that are physiologically very active and on lymphocytes and lymphoid tissue Most of the cutaneous affections that are amenable to x rays regardless of the cause are associated with hyperemia multiplication of tissue elements, overactivity of epithelial cells or dense lymphocytic infiltration, or a combination of some or all of these factors While the action of x rays on pathologic tissue is undoubtedly complex the inhibitory theory seems to be the most satisfactory explanation for this action

Action on Skin Diseases.—It seems worth while to apply this knowledge of the biologic action of x rays to a few of the well known dermatoses.

CONGENITAL ANOMALIES

The elevated types of vascular nevus (strawberry mark) yield to x rays and gamma rays and particularly to beta rays Even the cavernous angioma will yield usually to safe therapeutic dosage It may seem paradoxical but the port wine mark is exceedingly stubborn. The types that respond well begin after birth and continue to increase in size for weeks and months There is a numerical increase of the blood vessels which are dilated abnormally cellular and continue to develop by budding processes—in other words a new growth

in which the cells are embryonic in type When irradiated it is probable that mitosis is arrested new vessels cease to form and finally the poorly differentiated cells composing the vessels fail to be replaced and are absorbed. The troublesome port wine mark is fully developed at birth the cells are mature well-differentiated and not very active. It can perhaps, be likened to telangiectasia To cause an obliterating endarteritis in telangiectasia spider nevus, and port wine mark requires an amount of treatment that usually causes severe and permanent injury to normal tissue

In the hyperkeratotic group of congenital anomalies—ichthyosis, verrucous nevus keratoderma palmaris etc,—there is a congenital anomaly which interferes with the process of normal keratinization The result is a markedly thickened horny layer which exfoliates after irradiation It is possible that the temporary improvement is due to mitotic retardation in the basal cell layer As soon as inhibition ceases the abnormal keratinization continues.

DISEASES DUE TO LOCAL CAUSES

Of the many common dermatoses due to local causes with the exception of certain types of eczema and certain parasitic affections two only are treated with x rays—corns and warts—pathologic hypertrophies These lesions are characterized by acanthosis and particularly hyperkeratosis Presumably the increased activity is in the lower part of the rete and in the basal-cell layer Irradiation prevents further cell multiplication and the horny layer exfoliates If in the meantime, the local cause has been removed there will be no further development.

ECZEMA AND OTHER INFLAMMATIONS

The effect of x rays on eczema and other inflammatory dermatoses may be complex but it seems hardly necessary to invoke more than the usual inhibition hypothesis to explain the result. In the very early stage of eczema, when the objective symptoms consist of erythema and edema, irradiation appears to exert very little effect Even in vesicular eczema, if the vesiculation occurs before hyperplasia of the epidermis, treatment is not particularly efficacious After the lymphocytic infiltration and especially acanthosis have been established irradiation is usually very effective presumably by curbing mitosis and destroying very young cells In many inflammations eczema included, the epidermal response is exaggerated It is this overgrowth that x ray prevents or destroys The local lesions of eczema, psoriasis lichen planus, and many other inflammations are more or less self limited. They represent a reaction to an irritant and when the irritant is removed they usually disappear spontaneously Irradiation while promoting resolution of individual lesions does not seem to influence the etiologic factor or the disease Unfortunately this is true of many of the dermatoses.

Eczema and psoriasis occasionally become dermatitis exfoliativa a condition likely to offer considerably more resistance than do its predecessors even when the morphology is much the same The reason for the resistance is possibly because of a more virulent virus or increased *susceptibility to the virus* the resulting cutaneous reaction having a vitality that overbalances the inhibitory influence of therapeutic doses Similar reasoning may hold for diseases which usually are favorably influenced but which occasionally fail to respond to irradiation On many occasions the senior author has been asked to explain why lichen planus of the skin yields so readily to x rays while that of the buccal mucosa does not. The possible explanation is that lichen papules of the acute type will respond favorably as a rule to small doses regardless of situation. The lichen planus lesions of the mouth that are likely to attract attention and receive treatment are of the chronic type and correspond to annular and hypertrophic lichen of the skin which are much more stubborn than is ordinary lichen planus In addition, it is possible that environment plays a part. Mucous membrane lesions of many diseases may be more stubborn than similar lesions of the skin especially those that so often involve the cutaneous appendages because of the absence of these appendages in the mucous membranes.

It not infrequently happens that a person s first few attacks of eczema psoriasis or lichen planus will disappear promptly under the *influence of the x rays while later attacks may be irresponsive* The same phenomenon is observed in cases of mycosis fungoides leukemia cutis Hodgkin s disease cancer and though rarely in other affections Increased virulence of virus or increased susceptibility to virus may be factors here but it is also advisable to consider the possibility of acquired resistance to x-rays

When treating generalized dermatoses especially affections that are very 'radiosensitive such as mycosis fungoides particularly if large surfaces are exposed to fairly large amounts of radiation a febrile reaction is likely to develop together with a more or less generalized toxic rash. This is probably due to absorption of rapidly involuting lesions with consequent protein reactions A similar result is seen in some cases of tinea tonsurans

GRANULOMAS

The bacterial dermatoses have been mentioned already Sycosis due to fungi is cured with an epilating dose of x rays the same as is tinea tonsurans the fungi being removed with the hair Staphylogenic sycosis will respond to a few mild treatments occasionally but often it is necessary *to cause temporary and even permanent alopecia The pathology* of acne vulgaris consists of a preliminary inflammation of the distal third of the hair follicle and of the sebaceous duct and gland This results in hyperplasia and exfoliation of the glandular and follicular epithelium Inhibiting cell division and sebaceous secretion and de-

struction of the heavy lymphocytic infiltrate with liberation of protective substances are the probable functions of x rays in this disease.

Many of the bacterial dermatoses are classified pathologically as granulomas—diseases such as tuberculosis leprosy, syphilis rhinoscleroma and certain fungus affections (blastomycosis and actinomycosis) For our convenience may be placed here also certain nonbacterial granulomas such as mycosis fungoides leukemia cutis, and granuloma annulare The last is thought by many to belong to the tuberculosis group Mycosis fungoides and the entire lymphoid group of diseases (lymphoblastomas) respond quickly, as a rule although only temporarily to x ray treatment. This is due as already mentioned to the extreme "radiosensitiveness of all lymphoid tissue The lesions of granuloma annulare will usually undergo complete involution as a result of a single erythema dose The nonbacterial granulomas are the most susceptible members of this group The fungus diseases can be accorded second place as both actinomycosis and blastomycosis yield rather promptly as a rule to comparatively mild doses

Lesions of syphilis and leprosy will yield to some extent The more benign types of cutaneous tuberculosis—sarcoid and erythema induratum—are very susceptible The comparatively inactive atrophic type of lupus vulgaris with deeply embedded apple jelly nodules is particularly unyielding. The comparatively active hypertrophic lupus and ulcerated lupus are more susceptible, and the very active miliary lupus is even more susceptible. With the exception of syphilis it will be noted that susceptibility bears some relation to activity and duration The rapidly developing granulomas—actinomycosis blastomycosis granuloma annulare, miliary lupus—involute more quickly under irradiation than do those of slow evolution—lupus vulgaris and rhinoscleroma. It is significant that the most inactive granuloma, barring leprosy is the most resistant, namely atrophic lupus vulgaris. Such observations tend to support the theory of inhibition. Of course the infiltrating cell has something to do with radiosensitiveness The plasmomas (syphilis yaws) are not very sensitive nor are diseases such as leprosy in which the infiltrating cells are for the most part partially reverted connective tissue cells The most susceptible granulomas are those in which the infiltration contains a large number of lymphocytes

DISEASES OF THE APPENDAGES

All the appendages with the exception of the nails and especially the hair follicles are markedly influenced by irradiation. The comparative immunity of the nails may be due in part to filtration The comparative susceptibility of the hair follicles is perhaps caused by the rapid cell division and the large number of young cells always present at or near the bulb The action on the coil and sebaceous glands is presumably a retardation of physiologic activity Many fungus and bacterial affections of the hair follicles cannot be cured by roentgenization

without a defluvium. This is always so in tinea tonsurans and favus and very frequently in sycosis vulgaris folliculitis decalvans etc. In such instances irradiation acts as a depilatory the micro-organisms being removed with the hair

PRURITUS

It is stated repeatedly in the literature that x rays will relieve pain This is true when the pain is due to the pressure of painful lesions that have undergone involution as a result of treatment Occasionally x rays will relieve pain that is due to nerve inflammation—neuralgia. In this connection x rays will arrest itching that is secondary to some dermatosis and also it is very beneficial for local essential pruritus—pruritus without any discernible cause Certainly the result is not always psychologic. If it may be assumed that essential pruritus is due to inflammation of the collagen or sensory fibrils of the nerve it is conceivable that the radiation acts by inhibiting cell proliferation

NEW GROWTHS

There is an enormous difference in the susceptibility of various new growths to irradiation The pure basal-cell epithelioma is very susceptible as are also young keloids Squamous-cell epithelioma is much less susceptible Cutaneous fibroma myoma and neuroma hardly respond at all. The benign epithelial new growths—syringoma, tricho-epithelioma etc.—are very stubborn The same differences are noted in the sarcoma group Benign endotheliomas (moles) yield hardly at all. The giant-cell sarcoma is susceptible more so than either the spindle-cell or the round-cell variety These differences in susceptibility seem to be partly one of cytology and morphology The benign epitheliomas are quiescent lesions probably nevoid in character The cells are mature and differentiated and are not undergoing rapid division The basal-cell epithelioma when of pure type is composed of cells derived from the stratum germinativum which show no tendency to produce keratohyalin In other words they are immature and unspecialized the type of cell that one might expect to see easily influenced by x rays Prickle-cell or squamous-cell epithelioma is composed of cells that are undergoing fairly rapid division but the cells are less embryonic in type and presumably for this reason are more resistant Also the lymphocytic infiltration is much more marked in basal-cell epithelioma than in prickle-cell epithelioma a fact that may be of some importance Soft fibromas (rapid proliferation of young connective tissue cells) will yield to irradiation while hard fibromas which consist of mature differentiated fibrous tissue, are highly resistant. The difference in susceptibility between keloid and hard fibroma may be due to the fact that the former is comparatively rapid in its evolution

Acquired Resistance

Lesions of mycosis fungoides which are at first exceedingly susceptible to x rays finally cease to respond. This is true of the entire lymphoblastoma group of diseases The same phenomenon is observed in basal-cell epitheliomas. Occasionally, too, psoriasis, eczema, and other affections will behave in the same manner It seems that in certain diseases which have received long-continued treatment, the cells develop a resistance that is apparently transmitted to future cell generations This question of acquired resistance (x ray fastness) is an important one in dermatology especially when treating psoriasis, eczema mycosis fungoides and basal-cell epitheliomas

Idiosyncrasy

Idiosyncrasy for our purpose means a natural or an inherent tendency on the part of the skin to react vigorously to minute doses of x-rays The skin of the entire body should show the tendency at all times This excludes acquired susceptibility and variations in sensitiveness that will be discussed later also variations due to errors of technic and judgment. It includes only those variations for which at the present time there is no explanation True idiosyncrasy of mild type is probably common but as a rule the degree is not sufficiently great to be beyond the margin of safety for practical work in expert hands A severe grade of true idiosyncrasy is rare For various reasons it is difficult to detect mild grades of idiosyncrasy or to separate true mild idiosyncrasy from mild hypersensitiveness due to known causes In an attempt to do so MacKee and Eller concluded that approximately five per cent of unselected material (220 patients) showed mild idiosyncrasy The senior author and his associates have in the course of twenty years applied an epilating dose to the scalps of over 2,000 cases of tinea tonsurans without a single instance of permanent alopecia. Such observations refute the statements that severe grades of idiosyncrasy are fairly common.

Factors Causing Variation in Reaction.—It is well known that the skin of various persons and even that of the same individual will react differently under changed conditions These various factors will now be discussed separately

Age.—The skin of any given part of an aged individual is markedly less sensitive than that of an infant. There is also a noticeable difference between adults adolescents and children.

Sex.—The skin of females, as a rule, is slightly more sensitive than that of males.

TEXTURE —A thin fine skin is more susceptible than is a thick coarse skin

CIRCULATION —A skin that is pale or anemic will react less readily than one that possesses a good circulation The most sensitive skin in this respect is one that is hyperemic or congested

COLOR.—Blonds are usually more susceptible to x rays than are brunettes The Negro skin is the most resistant. All this however pertains to x ray erythema Dark skins pigment more easily than do light skins

LOCATION —Topographically there is a very pronounced variation in susceptibility In so far as concerns a visible reaction the least sensitive part of the body seems to be the scalp The face is probably the most sensitive part. The extensor surfaces are more resistant than are the flexor surfaces The flexures are very sensitive. There are important exceptions to these rules The thin skin on the extensor surfaces of the articulations reacts more readily than does that of the immediate vicinity The palms and soles on account of the thick horny layer are less sensitive than such flexures as the anterior neck and the axillae The mucous membranes appear to be more sensitive than the skin.

IRRITANTS —Vigorous irritants such as iodine chrysarobin, sulphur mercury tar salicylic acid etc., especially when used as strong ointments markedly increase the susceptibility of skin to x rays

SUBSEQUENT IRRADIATION —Skin that has been irradiated but not visibly injured does not appear to acquire a susceptibility to further irradiation provided that accumulation is avoided If the skin has been injured as manifested by a reaction or by sequelae it is likely to be more readily affected by subsequent irradiation

DISEASES —Certain diseases and conditions of the cutaneous envelope—eczema psoriasis etc.—seem to make the skin more responsive to irradiation probably because of increased blood supply Lesions covered by a very thick horny layer tolerate comparatively large doses because of the filtration (warts for instance) Certain organic and constitutional diseases especially those affecting the vasomotor system or the sympathetic nervous system such as hyperthyroidism, may modify cutaneous toleration

SIZE OF AREA.—A split pea-sized area of skin will tolerate several times the dose that may be applied to a large area with safety The difference in toleration between an area one inch square and an area four inches square is approximately 25 per cent Beyond four square inches there is no difference The phenomenon is due to the scattered rays

Fluctuation of Cutaneous Toleration —Variations in cutaneous toleration to x rays may occur in the same person at different times Such fluctuations when not due to technical errors are caused by variations in the general health vasomotor system nervous and endocrine systems etc.

Summary —1 Variations in cutaneous susceptibility to x rays due to known causes are of daily occurrence. These variations may be well marked They cannot be regarded as examples of idiosyncrasy

2 Slight variations in susceptibility of unknown and undiscoverable causes are not uncommon Some of these variations are probably idiosyncratic but this will not be known definitely until technic is scientifically exact

3 The existence of true idiosyncrasy of severe type is admitted but it is rarely encountered.

4 Individual peculiarities relative to pigmentation defluvium telangiectasia, atrophy etc. are common and can be regarded as probable examples of idiosyncrasy

Radiodermatitis

When the skin or mucous membrane has been irradiated with x rays or radium beyond the toleration point, an inflammatory reaction results When provoked by radium the reaction is termed radium dermatitis If effected by the x rays it is called radiodermatitis x ray dermatitis roentgen dermatitis x ray reaction x ray burn' etc. The term radiodermatitis may well include the reactions both of x-rays and the radioactive elements A reaction may result from a single intensive dose or it may be the cumulative result of several or many fractional applications

Latent Period.—After an erythema dose the first clinical manifestation of a reaction is seen usually about the end of the first week The length of this period depends upon the size of the dose—shorter with a heavy dose and longer with a smaller dose.

Electric or Transient Erythema.—Occasionally one encounters an erythematous reaction an hour or two after intensive roentgenization especially when the irradiated area is surrounded with lead foil that is not grounded The hyperemia endures for a day or two and disappears without leaving sequelae If the treatment happens to include the parotid glands they may become swollen and a little painful. These early temporary and harmless reactions not infrequently occasion considerable alarm because of the knowledge that true x ray reactions of the third degree begin very soon after irradiation Pfahler believes that they are caused by an electrostatic discharge

True X Ray Reactions of Skin.—X ray reactions may be divided into two types—acute and chronic. The acute type is subdivided into three degrees—namely first, second and third degrees

First Degree.—The first-degree reaction consists of simple cutaneous erythema or hyperemia. This may vary from a hardly perceptible flush to one that is intensely red and associated with slight clinical edema The reaction becomes manifest as a rule in from 5 to 7 days and reaches maximum development in from 10 to 14 days after which the bright red color changes gradually to dull red then to a brownish red and disappears usually in the third or fourth week. Pigmentation

Fig. 1—The patch above the elbow represents a first-degree x-ray reaction (erythema) The patch below the elbow is a mild second-degree reaction consisting of erythema and edema.

may remain for several weeks or months If the affected area involves a hairy part, depilation is apt to occur during the third week The alopecia may be temporary or permanent. The subjective symptoms consist of a sense of heat.

Second Degree —There is no sharp line of demarcation between reactions of the first and second degrees It is generally understood that if a reaction progresses beyond hyperemia and slight edema it is of the second degree A second-degree reaction is recognized by marked edema vesiculation erosion or superficial ulceration. The erythema of second-degree reactions is likely to develop two or three days earlier than that of the first degree In a few days the color is scarlet it then becomes purplish red (livid) after which there may be vesiculation erosion exudation etc. The exudation often dries into crusts The subjective sensation is a burning pain which may be severe Second-degree reactions heal spontaneously in from six weeks to three months de-

pending upon the intensity of injury and the extent of surface involved Hair in the irradiated area falls out in three weeks and the resulting alopecia is permanent The regeneration of epidermis is complete and if the connective tissue, basal-cell layer, and blood vessels have not been badly damaged and sequelae do not develop, the final result is clinically normal skin.

THIRD DEGREE.—There is no line of demarcation between reactions of the second and third degrees It may be said that if the ulceration or necrosis involves the true skin the reaction is one of the third degree. The first evidence of reaction (erythema) is likely to be seen within 24 or 48 hours, and in a few days it becomes of the livid or bluish-red type In two or three weeks the congestion and edema of

FIG. 1—A third-degree x ray reaction after most of the slough has separated.

the deep tissues become intense even to the extent of board-like hard ness the epidermis exfoliates leaving a denuded derma. One of two things may now happen The injured cutis and subcutaneous tissue may undergo ulceration or the affected parts may form a dry hard necrosed mass with crusted surface—dry gangrene In the latter in stance the necrosed mass surrounded by intense inflammation will remain apparently stationary for weeks or months eventually it is converted into a slough which is finally thrown off the result being a deep ulcer In either instance after a period of considerable ulcerative activity assuming that the injury is beyond immediate spontaneous repair the ulcer develops distinctive characteristics The abrupt mar

gins and the deep-seated floor produce a punched-out appearance. The absence of granulation tissue and the subsidence of reactive inflammation create a dry glistening floor In other words there is an exceedingly indolent ulcer Small comparatively superficial ulcers may begin to granulate in a month or two healing being completed in a few months The larger and deeper ulcers usually remain indolent for many months even years.

The cicatrix following healing of a third degree ulcer may be of excellent cosmetic quality Eventually however the scar is likely to be the site of undesirable disfiguring and even dangerous sequelae

The chief subjective symptom of a third-degree reaction is excruciating pain

FIG. 3 —Telangiectasia, atrophy pigmentation, depigmentation, sclerosis, and keratoses. The so-called "x ray skin or chronic radiodermatitis In the center of the area there is a prickle-cell epithelioma

Sequelae.—X ray sequelae may be the result of acute reactions or they or at least most of them may develop without an antecedent acute reaction due to long-continued treatment with very small doses. Some of them are disfiguring while others are dangerous The sequelae are commonly spoken of as chronic radiodermatitis In the vernacular this is called "x ray skin"

TELANGIECTASIA (VISIBLE DILATED CUTANEOUS CAPILLARIES) — Telangiectasia is more common after second and third-degree reac

tions than after a reaction of the first degree. However it should be emphasized that marked telangiectasia may follow a single very mild first-degree reaction When subsequent to third-degree and severe second-degree reactions, the telangiectasia is likely to assume the radiating type Telangiectasia may develop within a few weeks or a few months subsequent to the advent of the reaction but as a rule it makes its appearance between the first and the third year Occasionally its appearance may be delayed many years As a rule it is permanent, but it may eventually improve or completely disappear While it is not certain, there is reason for believing that telangiectasia never appears without at least one previous very mild reaction

Atrophy —Cutaneous atrophy is an exceedingly frequent sequel to acute reactions also it occurs frequently without antecedent reaction. The atrophy may be of several different clinical types It may cause a slightly depressed area. Wrinkling is the most common manifestation This may be so slight as to be almost imperceptible excepting when involving the face particularly near the mouth, and even here it may be noticed only when the muscles are used in acts such as smiling weeping mastication, talking etc. When of a more marked degree the wrinkling may be conspicuous even when the part is in repose. At times severe atrophy is manifested by parchment like skin, senile skin scleroderma or hidebound skin, etc Atrophy may appear in a few weeks or months but it is more likely to develop in a year or two subsequent to irradiation It is permanent and incurable.

Pigmentation —Tanning or pigmentation is common after reactions of all degrees and even without reactions As a rule it disappears in a few months although after severe reactions it may be permanent.

Hair Follicles —When hairy parts are irradiated with sufficient intensity to effect a first-degree reaction defluvium will usually occur in the third week. Complete and permanent alopecia follows reactions of the second and third degree as a rule The hair usually regrows after a mild reaction but it may not do so It is possible by the repeated application of small doses at properly spaced intervals to effect permanent alopecia without the advent of erythema. If regeneration occurs, the hair will begin to grow again in from one to six months, depending upon the dose administered If alopecia is present at the end of six months, it will be permanent.

Sweat Glands —The coil glands may regenerate completely after a first-degree reaction but there is likely to be a noticeable diminution in the secretory function A second-degree reaction will markedly reduce the activity of the glands and they are totally destroyed by third-degree reactions. The sudoriferous function may be lessened and even permanently arrested by repeated exposures without an accompanying reaction

Sebaceous Glands —A single first-degree reaction may permanently impair the function of sebaceous glands although this is not the rule Repeated erythematous reactions or a simple reaction of second degree will markedly reduce sebaceous activity as evidenced by a dry skin. Third-degree reactions completely destroy the sebaceous glands As with hair follicles and coil glands the sebaceous glands can be reduced or even destroyed by repeated mild irradiation without visible reaction.

Fig 4—Permanent ray al pecia with atrophy and telangiectasia.

Keratoses Late Ulceration Cancer —Keratoses are common after third-degree reactions are fairly frequent subsequent to second degree reactions and occur quite often following first-degree reactions and long-continued treatment without acute reactions The lesions occur in skin that usually is atrophic and often telangiectatic. X ray keratoses may consist clinically of nothing but a small firmly adherent scale or they may form a warty excrescence The lesions may develop within a few months after the healing of a severe reaction but as a rule it is several years before they make their appearance These keratoses are not epitheliomas but inasmuch as many of them eventually become cancerous they must be regarded as potentially dangerous

Ulcers may develop months or years after the healing of a severe reaction or in skin that has been subjected to long-continued treatment with or without repeated mild reactions Many such ulcers are the result of traumatism of devitalized tissue Such ulcers may heal

spontaneously or they may persist, resist treatment, and eventually become malignant

Cancer usually of the metastatic type develops secondary to keratoses or to ulceration Epithelioma has been known to occur within a year after a third-degree reaction but as a rule this unfortunate development does not take place for several or many years Cancers occurring in x-ray skin, because of the sclerotic tissue are apt to develop slowly and metastasis is usually delayed

CHRONIC RADIODERMATITIS —To some clinicians this term signifies an indolent ulcer resulting from an acute reaction of the third degree. Others employ it to indicate the so-called x ray skin, a skin that shows one or all of the sequelae already enumerated and which may be the result of a previous acute reaction or which may develop insidiously as a result of repeated irradiation over a long period of time It is obvious that chronic radiodermatitis may be atrophic hypertrophic, or ulcerative. X ray skin bears a striking resemblance to xeroderma pigmentosum sailors' or farmers skin, and senile skin

Treatment.—After a dose of x rays sufficient to cause a visible reaction has been applied, there is no way to prevent the reaction Also nothing worth while can be done to lessen the degree of reaction to shorten its course or to prevent sequelae

FIRST DEGREE.—First-degree reactions are treated with soothing lotions emulsions and creams—calamine lotion, Carron oil zinc oxide ointment boracic ointment, cold cream etc.

SECOND DEGREE —There is likely to be considerable discomfort associated with reactions of the second degree also a denuded surface and exudation Wet compresses of well-diluted Burow's solution (1–20), limewater watery extract of witch hazel, Carron oil etc. may give comfort. Soothing ointments may be used when there is no exudation. When pain is severe 5 or 10 per cent of benzocaine or beta-eucaine-lactate or butyrin may be added to whatever lotion oil, emulsion ointment or cream is being used

THIRD DEGREE —The most difficult problem in the treatment of severe extensive reactions of the third degree is to obtain relief from the intolerable excruciating constant pain that is so often present. Patients will welcome any new local application only to throw it aside in a few hours One remedy after another will be tried until the resources of the pharmacopeia and of the physician are exhausted Fortunately by that time the pain will begin to lessen and the remedy that is being used at the time or the physician who prescribes it will receive the credit. Psychologic influence can be used to advantage tact patience and constant encouragement are essential. The weight

of bedclothes thick pads and bandages is not well borne and should be avoided. The remedies already enumerated are the ones most used but they may have very little effect during the stage of gangrene or sloughing It is usually necessary to administer sedatives and hypnotics during the first few months After separation of the slough pain can often be controlled with local applications Indolent ulcers are apparently benefited at times by stimulation with ultraviolet radiation high frequency electricity and the various dyes such as scarlet red gentian violet, etc.

The best treatment for third-degree reactions is excision or when this is impossible plastic surgery If properly done if the entire affected area is removed in regard to both depth and circumference, pain ceases at once and grafts and flaps take well This saves months of agony additional months of inconvenience and most important of all it precludes the subsequent development of sequelae. If possible when dealing with large areas it is preferable to select a plastic surgeon who has had experience with cases of this kind The fresh leaf of Aloe vera has been found useful by several dermatologists and radiologists for the treatment of ulcerations caused by roentgen rays The gelatinous substance found between the outer hard coverings is held in contact with the ulcer by means of bandages A fresh application is put on every eight hours The beneficial effect is said to be due to vitamin effect Viosterol in aquaphor or lanolin in 6 to 12 per cent strength is also beneficial according to some Cod liver oil ointment has been used successfully for the treatment of x ray ulcerations

SEQUELAE.—Pigmentation and freckles disappear spontaneously Their disappearance may be hastened perhaps by the frequent application of desquamating lotions—lotio alba lotions and almond emulsions containing two grains of corrosive sublimate to the ounce Perhaps the best treatment for areas of permanent depigmentation is the daily application of walnut juice stain This will at least camouflage the condition for which very little that is worth while can be done.

Telangiectasia can be destroyed in various ways—electrolysis ultraviolet radiation (see later in this chapter) and solid carbon dioxide (see MacKee and Cipollaro Vol. I) Solid carbon dioxide must be used very conservatively because the tissue is devitalized and even short applications may cause deep ulceration and disfiguring scars The first application should be not more than one or two seconds with firm pressure Blistering doses of ultraviolet radiation with a water cooled lamp are efficacious but they are likely to emphasize the atrophy and depigmentation that are usually present The treatment of x ray telangiectasia is not highly satisfactory

There is no conservative treatment of any value for atrophy dry skin and permanent alopecia Keratoses if superficial can be successfully destroyed with electrodesiccation (Volume I) or with unfiltered beta rays of radium (see Volume II) Ulcers that refuse to

couraged After three to four days the splint may be removed by the surgeon and very slight gentle active exercise allowed for a few moments This should be repeated daily but the splint is reapplied after each session and kept on for approximately three weeks By that time the range of motion of the active exercise has considerably increased Heat, massage the whirlpool bath and exercises by special apparatus are added at the end of three weeks and kept up until practically full joint motion has been obtained Success in this arthroplasty as in all others depends upon the surgeon's ingenuity in working out methods for starting early heat massage and exercise and in daily increasing the dosage and upon his persisting in the same until function is obtained (see Fig 15)

Fig 15—*A* crushing injury of the elbow with six fractures compounded and severely infected. Figure illustrates the final result following arthroplasty and prolonged physical therapy *B* same case as Fig 5 a

PERIARTICULAR BONY OBSTRUCTIONS

Extension ankylosis is often due to bony deposits in the olecranon fossa of the humerus Removal of the mass is necessary When it is accompanied with irregular bony growths into the joint proper arthroplasty may be necessary Rotation of the forearm may be lost due to a fracture-dislocation of the head of the radius and this must be removed surgically as already indicated Bony growth or synostosis may develop between the upper end of the ulna and radius

which must likewise be carefully dissected out and a fascial graft placed between the remaining fragments of the two bones to prevent recurrence. Physical therapy is indicated at once in all these cases.

PERIARTICULAR CONTRACTURES

There are cases which have such marked soft tissue contractures about the joint that function cannot be restored by physical therapy methods alone These are the cases in which we are so often tempted to do a *brisement forcé* The usual form of deformity is stiff elbow in flexion position. When the biceps tendon and the brachialis anticus have become so contracted that they will not yield to physical therapy procedures operative treatment is indicated. The incision is made over the anterolateral aspect of the elbow along the biceps tendon The biceps and brachialis anticus muscles are exposed and the dissection is carried downward until the anterior aspect of the capsule and the tendons of these muscles are exposed The biceps tendon is severed obliquely and the brachialis anticus is dissected from its attachment to the coracoid process The capsule may have to be cut transversely before extension of the forearm is obtained Following this operation a posterior splint may be applied or better a Thomas arm splint with forearm traction The latter allows early massage and the traction can be released twice daily for gentle active exercise which should start the day following the operation The range of motion must be increased rapidly but the extension must be maintained for three weeks or more to prevent recurrence of the contractures

FLAIL ELBOW

Flail elbow when it follows injury or an arthroplasty must be protected by a hinged splint or converted into an ankylosis by an *arthrodesis operation* Physical therapy is indicated here to maintain good muscle tone (Fig 16)

POSITION OF FUNCTION —When arthrodesis is performed or when ankylosis of the elbow is inevitable an effort should be made to have the forearm in 45 of flexion and very slightly pronated

HAND AND WRIST

While our interest in this chapter is chiefly related to trauma of the joints yet it is impossible to consider these separately when it comes to the hand and wrist. So many injuries here involve more than one joint and in addition nerves tendons fascia and skin that an article dealing with restoration of function must consider all these possibilities

Loss of function in the hand can prove more disastrous to the majority of people than any other disabling joint condition Every injury

in the wrist or hand should be viewed by the surgeon as a potential crippling condition So many hidden injuries may be present and easily overlooked in the presence of a very apparent major injury that the greatest acumen is necessary to discover and repair each injury before irreparable damage has been done

Loss of function in the hand and wrist may be due directly to the trauma or indirectly to mismanagement during the period of treatment. The latter can very easily be a matter of wrong judgment in planning the proper surgical treatment

FIG 6—*A* flail elbow following arthroplasty *B* and *C* flail elbow protected by a hinged leather brace

Causes of Loss of Function—The commonest causes for loss of function in this region are

(1) Severe swellings of the hand and wrist due to large hematomas and edema following as a rule, severe crushing wounds or severe infection usually fascial space infections

(2) Ischemia due to the above swelling or to prolonged or too tight splintage or plaster cast and sometimes due to severe crushing injuries of the forearm or arm

(3) Fracture-dislocations especially in the metacarpophalangeal joints or in the carpal bones, as a fracture or dislocation or combination of both in the semilunar bone

(4) Severed tendons especially if accompanied with a joint injury

(5) Severed nerves especially if accompanied with severed tendons and joint injury

(6) Extensive scar formation such as the scars which follow electrical and other burns

(7) Colles fractures which very frequently result in deformity (There is one type of Colles fracture that invariably gives a deformity but all other types should give full restoration of function after healing Deformity will result if there is severe crushing and comminution of the lower end of the radius with much shortening This shortening is difficult and at times impossible to overcome it results in a change in the normal arc of the joint and is usually accompanied with marked cartilage injury (Speed) The altered level of the radial styloid process invariably gives deformity and the injured cartilage frequently results in a certain amount of arthritis which is often proliferative)

(8) Severed tendons high up in the forearm, which will cause a loss of function in the hand (Likewise excessive scar formation in the forearm may restrict tendon action with resulting deformity in the hand)

(9) Severed nerves anywhere in the forearm arm or in the brachial plexus nerves caught in callous or scar formation and cord tumors.

Prevention of Loss of Function.—The multiplicity of injuries which may follow severe hand trauma requires common sense and good surgical judgment if all the contingencies are to be met The question of prevention of loss of function must at all times be the first consideration

Prevention of Tenosynovitis Contractures Thickening of Aponeurosis —It is impossible to keep the hand or fingers immobilized for any great length of time without a certain amount of fibrosis occurring in the soft tissues especially in the tendon sheaths and about the joint capsules resulting in a tenosynovitis contractures of the capsule and thickening of the aponeurosis all of which may permanently restrict flexion or extension movements in the fingers or may require weeks and months of physical therapy treatment to overcome. Extensive prolonged swellings of the hand can act in exactly the same way as mechanical prolonged immobilization therefore one must relieve this swollen condition as rapidly as possible An ice-pack applied to

the swollen hand is sometimes sufficient, but if there has been hemorrhage under the fascia, this method is too slow Large, hot fomentations are likewise often sufficient but these hot fomentations must not be persisted in until the hand is water-logged and edematous The elevation of the hand, alternating hot and cold packs, the whirlpool bath, hot soapsuds soaks, large packs of equal parts of alcohol and glycerin or saturated solution of magnesium sulphate, all may be tried and found useful The surgeon should begin to worry about the persistent extensive swelling in the hand if it is not subsiding after 48 hr It may become necessary to make multiple small incisions and evacuate the hematoma although this is to be avoided if at all possible, as infection is liable to follow the procedure. A solid swelling is more dangerous than an edematous swelling. The latter seldom needs incisions while from the former large blood clots are often evacuated through incisions.

PREVENTION OF ISCHEMIA.— Ischemia should be feared by every surgeon who applies a cast to the forearm wrist or hand If the hand and fingers become swollen cyanotic, or blanched or even are cold and if this condition persists for a few hours, the cast should be cut either anteriorly or posteriorly and spread so as to relieve the pressure. No one should apply a cast or even double splints to the forearm and allow the case to go three or four days without the personal observation of the surgeon. It is far easier for ischemia and its subsequent contractions to develop than many physicians realize. Many ischemic contractions are never overcome, leaving the patient crippled for life

PREVENTION OF CONTRACTURES FOLLOWING INFECTIONS —Many prolonged and even permanent contractures of the fingers follow a hand infection which is treated by continuous hot fomentations over a period of ten days or two weeks. This is usually due to the fingers being held in a faulty position within the large fomentations and to failure to instruct the patient to move the fingers frequently Hot fomentations should not be continued too long They should be changed several times a day and at each change the patient should be instructed to flex and extend his fingers abduct and adduct his thumb flex and extend the wrist joint, and otherwise prevent stiffness from developing The supervision of these movements should not be left to the nurse who usually changes the hot fomentations At each daily visit the surgeon should inspect the hand and make sure that the patient understands and is carrying out his instructions. I have seen large fomentations applied to the hand and because of their weight, wristdrop develops. I have seen physical therapy administered for weeks to overcome this faulty position of the wrist. The importance of exercising the elbow and shoulder joint, and especially of keeping the arm at a right-angle abduction position during the period of use of large, hot fomentations has already been mentioned.

Treatment.—EARLY MOVEMENTS —Early and daily movements of the wrist thumb and finger joints are the prime essential in treating the majority of injuries of the hand Seldom are casts indicated in a Colles fracture or in carpal metacarpal or phalangeal fractures If a cast is used it should be changed to a splint within a very few days Seldom should any splint be left on in this locality for longer than a week without removing it for massage and gentle active motion daily or at the longest every other day Even in nerve injuries where rest is important the cock up splint or the posterior flexion splint if the latter has been necessary in order to overcome the shortening in the ulnar or medial nerve defect, should be removed after a week for massage of the forearm hand, and fingers and very slight, but some active motion of the joints and very slight passive movement of those joints which have lost their power of movement Casts and splints for injuries in the metacarpals carpals or forearm should never extend down over the fingers These should be left free for movement and movement should be insisted upon Even in plastic operations where the hand and arm must often be encased in a cast to hold them in apposition to the nose or face or when the hand has been buried under a pedicellate abdominal flap or in a skin flap on the buttock the patient should be instructed in shrugging the muscles even though he cannot move the fingers

ADEQUATE INCISIONS —Faulty incisions for the drainage of hand infections account for many permanent disabilities These incisions should never be made directly over a tendon Lateral incisions along the fingers will drain any tendon sheath infection. Through-and through lateral drainage is not always indicated and should be avoided whenever possible No surgeon should incise a hand without first familiarizing himself with all the fascial spaces as clearly outlined by Kanavel. Small inadequate openings and failure to discover deep-seated abscesses will often result in sloughing tendons and irreparable loss.

POSITION OF FUNCTION —In many severe injuries of the hand a certain amount of loss of function is inevitable Viewed from the standpoint of reconstructive surgery such a hand should be placed from the outset in the position of greatest function Fingers should not be allowed to stiffen in a completely extended position Many a man has had an extended stiff finger amputated because it was in his way when trying to work with the remaining fingers Attention to this principle of the functional position of the fingers will save months of tedious physical therapy made necessary by failure to correct a preventable condition The position of function implies that the wrist is slightly hyperflexed The palm is concave and the fingers are in the position of grasping a tumbler (Jones) or a ball In this position the thumb is abducted and the ball of the thumb can usually be

brought into contact with the fingers We are all familiar with the stiff fingers which are somewhat hyperextended in the two phalangeal joints Flexion at the metacarpophalangeal joint may be present, but the hyperextended stiff fingers are responsible for the total disability If they had been treated during convalescence in a position of semiflexion this flexion position at the metacarpophalangeal joints would then have meant 50 per cent or more of function

Operative Procedures —Operative procedures on the hand and fingers for the purpose of restoring function likewise require great surgical judgment. One must make sure that the joints are movable and can function before subjecting a patient to beautiful tendon operations. The tendon operation may be perfect but if bony ankylosis or soft tissue contractures make it impossible for the joints to move, nothing will be gained. Thick, deforming scars may be dissected from the palm or the tendons may be freed from scars, and yet function may not be restored because of faulty condition of the joints Again one type of operation on the hand may require very early and very active movements if success is to follow, whereas another operation performed at the same time, for example upon a nerve may require rest therefore it is foolish to perform both of these operations at the same time. The hand and fingers must be put in the best possible condition to make the proposed operative procedure a success This usually implies several weeks of very active physical therapy treatment preceding the operation

I recently operated upon a stiff phalangeal joint of the thumb The stiffness was due to a partial dislocation with a small fractured fragment which interfered with joint movement. When I first saw it, I advised operation The patient postponed operation for five months and then reported to the hospital to have it performed Upon examining the thumb, I found marked atrophy of the muscles both of the thumb and in the thenar space Electrical tests showed innervation present. The condition was largely due to atrophy from disuse. The patient was from out of town and was accompanied by his wife. The two were sent to Dr Coulter for physical therapy preliminary to the operation Three treatments were given and during these treatments the wife was carefully instructed relative to massage and redevelopment muscle exercises They then returned home and the wife carried on this treatment. When they returned at the end of three weeks we had a thumb worthy of operative effort The operation was a success due to the fact that the patient had sufficient muscle power and had been sufficiently trained so that he could carry on early active movements

As a rule old disabling conditions of the hand should receive heat by means of hot paraffin baths whirlpool baths very active hard massage and passive and active exercises for several days preliminary to the proposed operation. Often one will see sufficient improvement

by these methods to justify postponing the operation and several hands on which I have contemplated operations have recovered solely by these methods

When an operation for restoration of function is contemplated on the hand or fingers, the strictest asepsis must be maintained and the least possible traumatizing of tissues must be done if the operation is to be successful Infection will destroy tendon and nerve repairs and plastic operations upon the hand in the majority of cases Every effort therefore must be made to avoid infection The more bloodless the operative field the less trauma will be done The tourniquet therefore is essential Many of these operations are long and tedious and an ischemia may develop from too prolonged use of the tourniquet For this reason the inflated bag of a blood pressure apparatus over the biceps is the best form of tourniquet to use. Occasionally the bag can be deflated restoring circulation in the forearm and hand and after a few moments it can again be inflated Rough handling of the tissues too severe retraction especially by rake retractors and dry sponging all predispose to adhesions with subsequent contractions and failure of operation

COLLES FRACTURE

Colles fracture is the commonest injury involving the wrist joint. Every such fracture should be reduced early under either local or general anesthesia. The purpose of reduction is to secure the most perfect alignment of the fragments. Impaction may occur and may render reduction most difficult. Frequently there is serious derangement of the wrist joint arc. The perfect correction of all these conditions can seldom be attained without an anesthetic. As soon as possible after reduction is made an x ray film should be obtained, and if almost perfect realignment of the fragments and correction of the joint axis have not been obtained an immediate second or third attempt should be made. If a general anesthetic has been given the patient should not be allowed to awaken until one is sure that the reduction has been completed This, of course, is one of the greatest advantages of local anesthesia.

In many Colles fractures there is very little displacement and practically little manipulation is necessary In these a simple posterior splint coming down to but not including the fingers is all that is necessary After one is sure of his reduction in the more serious Colles fractures, a posterior molded plaster splint again is usually all that is necessary In fact, a Colles fracture once perfectly reduced seldom flies out of position

Movements of the fingers the first two or three days are usually painful, but the importance of movement must be stressed and after one or two days assisted active motion should always be started in the fingers

In even the most serious Colles' fractures the posterior splint can be removed on the third day The forearm should be carefully laid upon a flat, even surface, and heat in the form of hot packs and infra red light or an electric baker can be administered for a few moments, followed by careful gentle massage from the fingers up to the elbow To be of the greatest benefit this massage should be rhythmical and always in the same direction. It shou d be in the line of the venous flow In the absence of the apparatus for application of heat alcohol, camphorated oil or warm soapsuds may be used with the massage After the splint is reapplied and before the bandage is put on the forearm is turned over and its flexor surface is massaged usually with alcohol. At the same time the fingers are exercised

On the fourth or fifth day when the above treatment is administered the patient is instructed to move his wrist joint to a slight degree It is interesting how much movement some of these patients can stand. I have never seen the fragments of the fracture displaced by active movement. Forceful passive movement, of course is definitely contraindicated Every day and at the least every other day after this the heat massage and exercise treatment should be administered and increased in dosage Seldom is the splint necessary beyond two weeks It can be replaced by a firm bandage or wristlet if the patient is fearful of having it free too soon Often during the third week I have the patient go without his splint during the day and apply it at night.

In a certain number of these Colles fractures there are still swelling and limitation of motion at the end of three weeks These cases are referred for more active physical therapy consisting of prolonged baking immersing of the hand and wrist in a hot paraffin bath immersion in a whirlpool bath, followed by 30 min of massage, and by assisted active and active exercises Certain apparatus may be used to develop exercise for example the turning of a crank attached to a small wheel the carrying of weights the twirling of Indian clubs and occupational therapy for example the use of a hammer several times a day The more active movements here described can be started as a rule after the fourth week and should be persisted in until full function is restored. Loss of function in too many Colles fractures is traceable to loss of interest on the part of the surgeon after the splints are removed

In old malunited Colles fractures (and the earlier the malunion is diagnosed the better the prospect of functional restoration) refracture and realignment of the fragments approximating normal anatomic conditions is definitely indicated. As a rule these malunions can be broken up by the use of a Thomas wrench. The procedure requires general anesthesia. Often a week of very thorough preliminary physical therapy is indicated before attempting refracture and realignment

of fragments Following the procedure physical therapy should be administered as described above the more active movements being delayed possibly a week or two longer than in the case of the recent fracture (Fig 17)

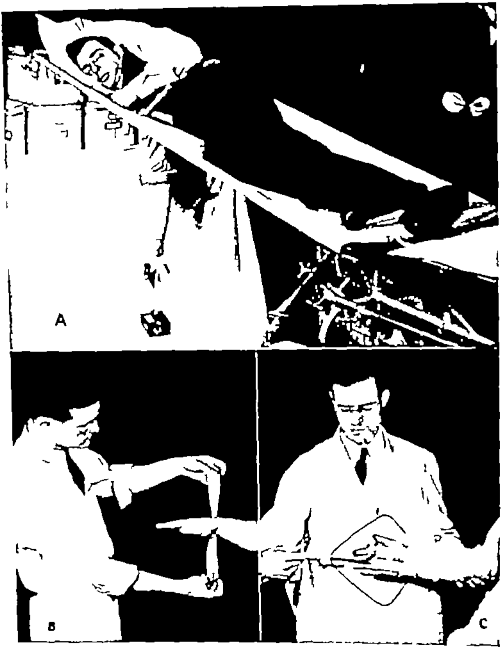

Fig 17—*A* case f Colles fracture being reduced by Dr R. R. Duff's method of gravity and weight traction *B* method of pplying traction strips in same case *C* method of pplying banj splint with traction strips attached to splint in same case.

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Dislocations of the individual carpal bones are not common. When dislocation occurs it usually involves the semilunar bone Im mediate reduction if possible is indicated but if complete reduction is impossible it is far better to make an incision and remove this bone.

Failure to recognize this dislocation or attempts at reduction with incomplete success account for a certain number of cases of wrist joint loss of function When seen late it is best to remove this semi lunar bone followed by traction and early active movement. Even before the wound is healed massage and exercise as outlined under Colles fracture are indicated

Whenever traction is used in any joint condition, especially the wrist joint, it should be frequently released to allow assisted active and active movement.

Complete dislocation of the wrist is comparatively uncommon. Complete dislocation of this joint is always accompanied by extensive injury to the capsule the ligaments and possibly to the tendons

When seen early manipulation under anesthesia is usually successful Old dislocations will require traction and the overcoming of con tractures by heat and heavy massage for a number of days before attempting the reduction

Following reduction the same physical therapy maneuvers as out lined for Colles fracture are indicated Accompanying injuries of course must be repaired to insure function

Sprains of the wrist joint frequently follow falls on the extended hand backfire of a motor when attempting to crank it sudden jerks or twists when attempting to jump onto a moving street car etc. A sprained wrist should always be x rayed to rule out the possibility of fractures

A true sprain of the wrist joint often accompanied by sprains in the metacarpophalangeal thumb joint and by tenosynovitis yield more readily to early active physical therapy treatment than they do to splints casts and disuse

The early use of diathermy followed by immersion in a hot whirl pool bath and by massage (gentle at first and increasing in force as the days go on) will usually result in the cure of a sprained wrist within two to three weeks Between treatments the patients are often more comfortable if a wristband or tight strapping is used

Strains of the wrist joint and tenosynovitis of either the flexor or extensor tendons in the lower forearm are not at all uncommon These are usually occupational conditions I have seen a clerk taken from his usual work and sent to the packing room during the holiday season develop this condition after two or three days of using the hammer

RADIOCARPAL AND CARPAL INJURIES

Severe crushing injuries of the wrist and *penetrating injuries* such as gunshot wounds, are frequently followed by infection. Adequate drainage of the infection is necessary Frequently there are open wounds on the flexor surface with or without involvement of the flexor tendons It is far better to let these wounds heal than to attempt to drain the infected wrist joint through these accidental openings A dorsal lateral incision, usually on the ulnar side, is the best approach for drainage of the wrist joint. It may be necessary to make bilateral incisions but more to the dorsal side.

The prevention of disabling deformities by placing such a wrist joint in the position of function—i.e 30° to 35° dorsiflexed—is imperative in such injuries. This may be accomplished by a cock up splint.

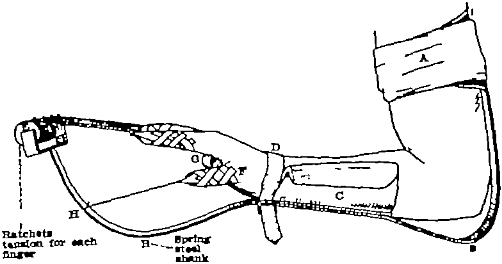

FIG. 8.—Method of traction used by Sir Robert Jones in injuries of the wrist joint. The method is also applicable f traction of stiff fingers. (From Sir Robert Jones' "Orthopedic Surgery of Injuries.)

Traction keeping the carpal bones separated as much as possible, and especially separation of the radiocarpal joints is extremely important in the presence of a wrist joint infection. This can be accomplished by a banjo splint applied to the forearm with a strong wire loop extending downward six to eight inches below the fingers. Adhesive webbing can be attached from the web to the tips of the fingers and thumb with a rubber band extending from the adhesive webbing down to the steel wire loop of the banjo splint (Fig 18)

Many of these cases are bedridden and can well be treated with a Thomas arm splint the traction being applied from the fingers to the end of the splint. The chief point to remember is that function can later be more readily restored in the damaged wrist joint if traction and dorsiflexion have been maintained

to 10 days the traction should be released for assisted active and active movements Heat, massage and exercise interspersed with continuous traction for at least a month will give fairly good function to the wrist joint

Loss of rotation due to strong fibrous or bony ankylosis between the radio-ulnar joint is extremely disabling The position of function for the forearm when rotation is threatened or inevitable is slight pronation that is about 25 of pronation from the medial position When this condition is threatened an arm should never be treated in complete supination or complete pronation It is best to keep them in the above position from the outset.

Jones has described an operation for the relief of this condition He advocates the removal of approximately a quarter of an inch of the ulna just above its head He reports good results in the restoration of rotation *Massage and exercise started early are necessary following this operation*

METACARPAL AND PHALANGEAL JOINTS

Dislocations of the carpal metacarpal joints are not common except in the thumb They are usually easily reduced but may be difficult to hold in reduction Firm felt padding over the point of dislocation with splintage is necessary

In the case of a dislocation of a thumb traction and abduction with pressure directly over the dislocation are usually sufficient. It may be necessary to maintain traction with the thumb extended If possible this should be avoided but when necessary the thumb should be released after one week for intervals of massage flexion and adduction exercises These exercises and massage are likewise imperative in the fingers when the dislocation involves these. As a rule two weeks are sufficiently long for immobilization followed by one to two weeks of very careful active motion before full use of the hand is resumed.

Dislocations of the metacarpophalangeal joints and phalangeal joints are fairly common The distal bone is usually displaced posteriorly These dislocations may be only partial may be subluxated and may then fly back into position so that upon examination no dislocation is found Nevertheless the damage to the capsule with the accompanying synarthrosis is very disabling and may result in a permanent deformity as is so often seen in baseball fingers

These dislocations must be reduced by manipulation consisting usually of marked hyperextension of the distal bone which should be gradually pushed over the proximal joint surface until it drops into position Open operation is often necessary but is usually neglected until the stiffened joint sends the patient for reconstructive surgery Following the reduction of any of these dislocations a simple dorsal

Rest is imperative to relieve the condition, especially the sense of crepitus and pain observed in the tenosynovitis A light splint is often necessary to obtain rest It should be removed once or twice a day for heat very gentle massage, and gentle exercise. The patient should be warned not to move the wrist joint beyond the point of pain With the subsidence of pain active exercise can increase As a rule these conditions are quite pronounced before the patient seeks advice and from two to three weeks are required to accomplish the cure

FRACTURES OF THE CARPAL BONES may result in stiffened wrist with difficulty in flexing the fingers This is usually due to failure to prevent the wrist flexion which is prone to follow these fractures. Traction and dorsiflexion are likewise indicated in carpal fractures

In old cases with stiffened wrist joint, weakness in the hand and loss of complete flexion power usually demand strong manipulative surgery This is one of the conditions in which manipulation under anesthesia is justifiable. The purpose should be to produce strong traction and gradual correction of the partially flexed wrist, bringing it up into a position of hyperdorsiflexion. This should be followed by the cock-up splint which is removed daily for heat, massage and exercise. After approximately one week the splint can be removed for longer periods and the hand and wrist immersed in a hot paraffin bath a whirlpool bath or a hot soapsuds local arm bath, followed by heavier massage and more marked exercise. It usually requires from four to six weeks to overcome this deformity

STIFF WRIST the result of fibrous adhesions may be overcome by strong manipulation under anesthesia if this is followed immediately by heat and light massage to prevent too great a reaction. Personally I prefer to treat stiff wrist joints which are not due to bony ankylosis by strong traction heat and massage or by the gradual manipulation of the wrist joint, pushing it toward the dorsiflexed position after a period of prolonged heat and massage A cock-up splint should always be applied to maintain the dorsiflexion, and the cock up position should be changed from day to day in order to maintain the improved position. The slower method is surer than *brisement forcé* under anesthesia, as it does not run the risk of tearing the ligaments and the contracted capsule with the subsequent marked reaction

Arthroplasty of the Wrist Joint.—When bony ankylosis seems inevitable every effort should be made to have the wrist joint stiffened in the functional position viz. slightly dorsiflexed. If this has been accomplished arthroplasty is seldom indicated following severe injuries. If free rotation of the forearm is present, the stiff wrist joint in hyperextension is preferable to a wrist arthroplasty

When an arthroplasty is performed traction should always be used to maintain the necessary separation in the new joint. After a week

one week in order to prevent a stiff joint Finger traction from the outset is one of the best methods of treating this condition. Considerable movement can be maintained while the skeletal traction is in use

FRACTURES OF THE METACARPALS tend to bow forward thus shortening the metacarpal and destroying the normal arc of the metacarpophalangeal joint. The knuckle is lost and the head of the metacarpal can be felt in the palm. This deformity frequently results in a stiff metacarpal joint and often involves the function of the adjacent fingers For this reason it is imperative to get good alignment in these metacarpal fractures.

FIG 10.—Severe crushing injury of the hand with fractures of the third and fourth metacarpals f proximal phalanges.

BENNETT'S FRACTURE consists of a fracture at the base of the first metacarpal and extends into the joint This fracture frequently appears after a fist fight Traction with the thumb in the fully abducted position is the best method of overcoming this deformity and of protecting the joint function

Physical therapy methods as outlined for dislocations must be followed in all these fractures and fracture-dislocations

STIFF METACARPOPHALANGEAL AND PHALANGEAL JOINTS are usually multiple and are due to marked fibrosis contracted capsule and synarthrosis these conditions following serious multiple injuries of the hand often accompanied with fractures or following prolonged disuse and fixation or following ischemia, make up a fairly large part of reconstructive surgery The surgeon s ingenuity is taxed to the limit

gutter splint or one made from plaster is sufficient After a week it should be removed for heat, massage and exercise For at least three weeks only flexion exercises should be attempted, as redislocation by active extension is fairly easy

OLD STIFF FINGER JOINTS FOLLOWING DISLOCATIONS either non reduced or only partially reduced usually require operative procedure. The joint should be approached by a lateral incision and the capsule of the joint exposed and incised vertically It may be necessary to incise on both sides of the joint and include the ligaments Strong traction hyperextension and direct pressure over the joint are then used to reduce the dislocation.

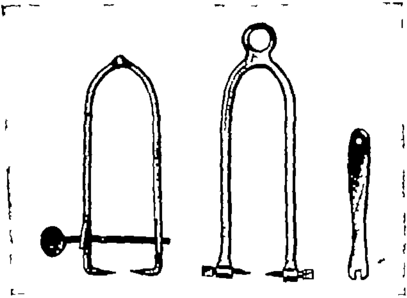

FIG. 19.—Author's finger caliper for skeletal traction

Following this operation I usually apply the Ellis Mock finger calipers (Fig. 19) to the distal phalanx or the phalanx just below the dislocation and institute strong skeletal traction by attaching the calipers to the hoop of a banjo splint The vertical incisions in the capsule are pulled into a somewhat longitudinal incision by strong traction thus giving increased capacity to the joint capsule after healing

After the third to the seventh day traction is released temporarily to allow slight active exercise The amount of exercise is increased each day thereafter The traction is maintained from two to three weeks Heat the hot paraffin bath massage, and exercise are continued until full function is restored.

FRACTURES INTO THE JOINTS must be reduced and immobilized but one should strive to start active movement early often at the end of

to prevent this condition in the presence of such severe crushing injuries as are shown in Figure 20 The fractures in this case were treated by skeletal traction leaving the soft tissues exposed for treatment (Figs 21a 21b) As a rule in the resulting deformity the hand is slightly cyanotic, a clammy sweat is present, the skin may be stretched and shiny and there is definite atrophy in the thenar and interosseous spaces The fingers are stiff or bend only slightly and are usually extended or only slightly flexed In other cases due to old nerve injuries there may be marked contractions giving the clawhand Rarely is the hand stiffened in the position of function that is in the position to grasp a tumbler Such a hand is frequently accompanied with a partially stiffened partially flexed wrist joint. The thumb is usually pulled in toward the palm in adduction deformity

Viewing such a hand one feels that the impairment to its blood supply from the various causes of ischemia from prolonged swelling immediately following the injury or from the atrophy which follows disuse of the member is largely responsible for the congealed condition of the hand and the fibrosis which accompanies it. No condition calls for greater effort on the part of the surgeon and the physical therapy expert. Seldom has the surgeon the time and patience to render the necessary physical therapy to restore even partial function to such a hand He must depend upon the specialist and his trained technicians who are thoroughly familiar with the various methods and modalities necessary to restore function

Forceful flexing or bending of such stiffened fingers when first seen will serve only to cause great pain and frighten the patient He becomes like a colt that is roughly bridled for the first time If a physician has made his patient afraid to let him touch or even slightly manipulate the hand the battle has already been lost because the necessary coöperation of the patient will not be restored or obtained Gentleness therefore is the first essential The second essential is never to bend stiffened fingers beyond the pain point The third essential is to warn the patient and everyone connected with the case that it may take weeks or months to secure even a partial result Finally the fourth essential point is for every physician to know that forceful manipulation of such fingers under anesthesia practically always results in a marked traumatic reaction with a definite increase in the disability

Seldom will the condition of stiff hand as described above develop in a patient who has been treated from the onset of his injury by the combination of surgery and the necessary physical therapy measures for preventing such a condition If however in spite of all efforts or because of some unforeseen accident a case has developed into this typical stiff hand the treatment should be continued from the viewpoint of restoration of function Do not let the patient become discouraged or lose confidence Do not lose interest in the case yourself It will require long painstaking effort close attention

FIG. 21A.—Same as Fig. 20 with author's finger callipers attached for skeletal traction, leaving crushed soft tissues exposed for treatment

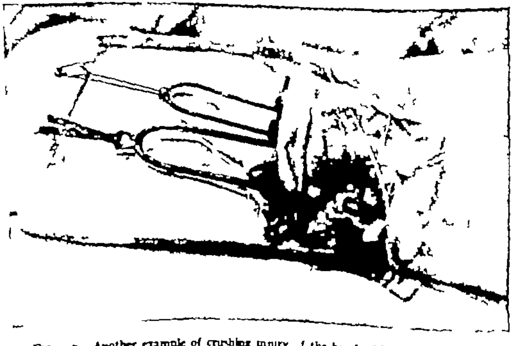

FIG. [illegible]—Another example of crushing injury [illegible] the hand with fracture in the prox[illegible] imal phalanx of the fifth finger treated by skeletal traction with [illegible]uthor['s] calliper at[illegible]tached to a banjo splint.

inside boiler is filled with paraffin, such as is used in preserving These cakes of paraffin can be purchased at any grocery store The cakes of paraffin are now melted by hot water in the outer boiler—all except a small piece *If a piece is still unmelted the paraffin is not too hot* if all is melted it may get too hot, and a thermometer becomes necessary *The hand is placed in the wax for one minute*

FIG. 2 —*A* stiff fingers being placed in a paraffin bath *B* fingers and hand immersed in paraffin bath *C* hand removed from the bath and coated with hot paraffin *D* this hot paraffin glove after it hardens, is easily stripped from the hand and fingers.

to the smallest details, constant supervision of the physical therapy technician and the maintenance of this program for weeks and months to restore function but complete or almost complete function is possible if one sticks at the job Most of the cases of this nature will drift to a surgeon after the condition of stiff hand has developed They usually come for operative treatment. Many things must be done before operation is considered if indeed it is eventually necessary

Methods of Treatment.—Improvement of the circulation is one of the first considerations Jones very aptly refers to this as "circulatory gymnastics" All methods which cause a vasodilatation in this extremity will improve the circulation Many of these methods will, at the same time, soften the skin and the contracted aponeurosis and help redevelop the atrophied muscles, the combined methods will have a cumulative effect upon the ultimate desired result. In considering the various measures independently I want the reader to visualize the sequence of action and the adoption of several of the methods at each séance of treatment instead of thinking of them as separate measures any one of which may suffice

Contrast Baths —Contrast baths consist of soaking the hand in hot water hot soapsuds or hot camphorated oil for 12 min then immediately immersing the hand in cold water for 3 min This should be repeated three times at one sitting The sudden contrasts in temperature give a marked vasodilatation and are very efficacious for improving the circulation They should be repeated daily The temperature of the hot bath should be approximately 106 F (41 1 C) and can be increased gradually to 112 or 118° F (44.4° to 47 7 C) The temperature of the cold bath should be approximately 40 F (4.4 C)

Elastic Bands —Bier's method of promoting hyperemia in the extremity by the use of elastic bands around the forearm or by cupping or by more recent methods of motor-driven suction apparatus all are beneficial in increasing circulation

Hot Paraffin Bath —The hot paraffin bath improves the circulation softens the skin, fascia and soft tissues prepares the hand and fingers for massage and is one of the most helpful measures that can be adopted. The patient can be instructed in making a paraffin bath to use at his home and he can use this method two or three times between treatments provided it is not contraindicated by some traction apparatus (Fig 22)

The paraffin bath for the hands can easily be prepared at home by using a double boiler ordinarily used for cereals This should be large enough for the hand to be placed in it up to the wrist. The

would fit the patient s deformed hand A ball of dental wax is softened in hot water and then put around the handle say of a hammer It is then dipped in cold water and immediately hardens becoming a definite part of the handle The handle is then dipped in hot water until the wax is softened again and the patient grasps the ball of wax as far as his restricted flexion movements will permit. An impression is made in the wax of each finger and thumb The handle is then submerged in cold water until the wax hardens The patient now has a tool with a handle that exactly fits his deformed hand He uses this in the workshop and carries it back to the ward or to his home and uses it several times a day as a means of exercise As the fingers flex further and the grasp improves the wax can again be softened and a new impression of his grasp made Since the War I have used this with great success on a number of patients

Combination of Different Forms of Treatment —Many com binations of the above maneuvers giving heat and exercise at the same time and massage and hydrotherapy simultaneously and even occupational therapy and hydrotherapy are utilized thus

(a) A favorite therapy exercise of mine is to have the patient make 12 pulp balls and give them to me on my visit the next day He is given a bucket of warm water into which he places a sheet of newspaper He then immerses the stiff hand in the bucket of water and proceeds to work the sheet of newspaper into a pulp ball The num ber of pulp balls he is to make is increased two a day This is a very homely method but extremely efficacious (Fig 23)

(b) The whirlpool bath has been mentioned many times in the text and has already been described. It is of great value in treating these stiff hands While the hand is submerged in the whirlpool bath or even a local bath massage can be administered to great advantage.

(c) Women patients have reported that washing dishes or wash ing clothes in hot water has been of great assistance in overcoming their deformity Men patients should not consider it effeminate to try similar methods

Traction —Traction is mentioned last but in a great many cases it is applied first and proves of the greatest value in overcoming the stiffened finger joints In some cases continuous traction is indicated while in others traction apparatus is put on at night and works while the patient sleeps. So many different forms of traction apparatus have been described that no effort will be made to enumerate them here. The glove traction was developed during the War Captain Abbott at the Edinburgh War Hospital is given credit by Jones for first using this method He fitted a glove to the hand and attached elastic bands to the finger tips of the gloves and then attached the opposite end of the rubber bands to a dorsal plaster splint extending well beyond the

taken out for two minutes and placed in for another minute. Keep this up for 10 min Then allow wax to harden and remove as a glove. The temperature of the paraffin bath is approximately 110° F (43 33° C)

MASSAGE.—Massage should be very gentle at first and then gradually increased, but never to the pain point. It should consist of stroking at first and later stroking and kneading, usually from the tips of the fingers upward through the palm, wrist, and forearm, following the line of venous flow It should be persisted in for 30 to 45 min Each séance is of importance and increases in importance as the case progresses toward recovery

MUSCLE AND JOINT REËDUCATION —Muscle and joint reëducation should be interspersed at frequent intervals during the 45 min. of massage This variation prevents both the patient and the technician from becoming fatigued. Many of these patients have forgotton how to close the fingers and must be reëducated Flexing the same joint on the opposite hand while attempting to flex the injured joint is an excellent means of reëstablishing joint habit. At first, muscle training exercises consist of having the patient concentrate upon the effort of flexion or extension even though he has no power of performing the movement at the same time the technician flexes or extends the finger as far as possible without causing pain. This is tedious work especially when every joint in the hand must be treated in this manner The surgeon or if the case has been referred to a specialist in physical therapy the latter should frequently supervise the treatment to make sure that none of these steps are being neglected.

EXERCISE —Exercise especially voluntary exercise by the patient himself is of the greatest importance We can perform all the other measures, but unless the patient will coöperate to the fullest extent in developing voluntary exercises, function will never be restored At first exercises may have to be passive later, assisted active exercises may be added and finally exercises may be performed by the patient himself Resistant movements are the best, that is, flexion or extension while the technician is resisting the movement. Many mechanical devices have been made to stimulate exercise in the fingers. Those which require voluntary effort on the part of the patient are the most successful

OCCUPATIONAL THERAPY —Occupational therapy which furnishes one of the best forms of stimulating exercise should be instituted as early as possible Dr Allen of Indianapolis early in our participation in the World War first suggested the use of dental wax applied to a hammer saw and plane or similar tools to make a grasp which

a woven-like manner around each finger from the web to the tip, and to the ends of the adhesive straps are attached strong rubber bands. The opposite ends of these bands are attached to the loop of the banjo splint (see Fig 18) As the flexion of the fingers improves the wire loop can be bent into a position of greater and greater flexion. The bands should be tightened as the patient develops greater

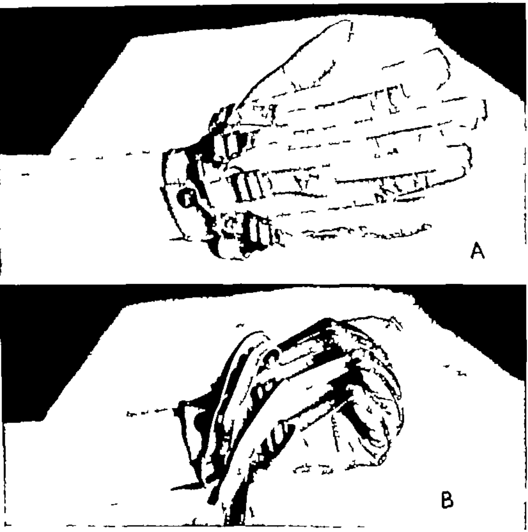

FIG. 14—A method f glove traction used by a thor B same as Fig. 14, a.

tolerance The traction must be freed several times a day for active exercises by the patient, especially exercises aimed at extension and then flexion to the point thus far gained. Traction is always necessary where there are marked contraction and stiffness in the phalangeal joints Failure to use traction in these cases jeopardizes the result. Only slightly forcing flexion or conversely extension in these joints

fingers The rubber bands gave a constant pull extensionward. Many variations of this principle have been made, notably, straps sewed to the tips of the glove fingers and extending backward through rings or leather loops to a wristlet attached to the glove and containing buckles The patient is instructed to tighten these leather bands in the buckles until he has as much extension traction on the flexed fingers as he can stand Both of these procedures are reversed when the

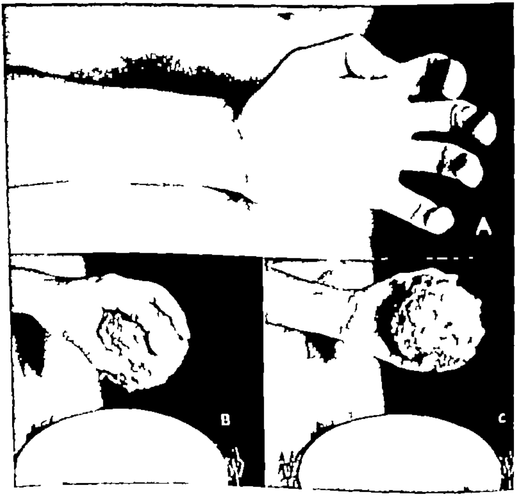

FIG. 23—*A* deformed hand following severe infection *B* same patient making pulp balls from newspaper *C* same as Fig. 23 b.

fingers are in extension and flexion traction is desired which is the usual condition in the stiff hand (Fig 24)

The banjo splint—that is a loop of strong wire attached in a plaster cast around the wrist and lower forearm each leg of the loop running down alongside of the hand and the loop itself protruding beyond the fingers some six inches—forms the base for most finger traction used today Two strips of adhesive are then interlaced in

of these conditions In all these cases the principles of physical therapy including traction and splintage, are definitely indicated in the treatment

Hip Joint

Associated Disturbances.—Loss of function following injuries to the hip joint are often associated with functional disturbances in the knee and ankle joint

In fractures of the femur disuse from prolonged immobilization often results in fibrosis both in the hip and knee joints

Traumatic arthritis is not at all uncommon in the hip joint, especially in older individuals It may follow a direct blow over the hip joint or force applied indirectly to the hip joint as when a patient falls a distance and alights upon his feet. Frequently the first x rays of the hip joint will show some osteo-arthritic changes present in the uninjured as well as in the injured joint and also present about the sacro-iliac joints A later x ray say three months later may show a definite increase in the osteo-arthritis of the injured hip joint with no change observed in the later film of the uninjured hip This is definite proof of an aggravation of an old osteo-arthritis of the hip which was latent and is a very common phenomenon. In older individuals it is always wise to x ray both hips for comparison.

Fibrosis may follow a suppurative arthritis of the hip joint. As a rule however the acetabulum the head of the femur and occasionally the neck of the femur are involved in a suppurative arthritis developing an osteomyelitis and marked destruction in and about the hip joint, which requires operative treatment. Another not infrequent cause of hip joint loss of function in the presence of a suppurative arthritis is the spontaneous dislocation of the hip joint which usually occurs in the presence of a long-continued suppurative process in this joint.

Bony ankylosis usually follows trauma of the hip joint whenever a suppurative or tuberculous infection supervenes.

Prevention of Loss of Function.—Traction treatment of fractured femurs especially skeletal traction permits of early mobilization of the hip joint and does away with many of the cases of fibrosis

In intracapsular fractures of the neck of the femur Whitman's abduction method with the body cast may be used for a great many weeks without loss of function in the hip joint. However in many cases prolonged physical therapy methods must be used to restore function. Recently Jones of California has developed a traction apparatus (Fig. 25) which can be applied with the fixed arm of this instrument in a plaster cast on the lower normal leg and with the movable arm attached in a plaster cast on the lower leg of the injured side By means of the screw shaft, traction can be applied to the injured leg with countertraction in the fixed arm of the instrument attached to the well leg I have used this in three cases in which the

may so erode the joint surfaces that a traumatic arthritis is developed by the treatment

In a few obstinate cases I have used Mock's finger calipers attached to the distal phalanx, combined with a banjo splint to obtain necessary traction Likewise I have used finger nail traction A hole is bored through the distal edge of the nail and a soft wire or silk thread is drawn through the hole The rubber band is attached to this and then to the loop of a banjo splint In case of traction on one finger only a single splint protruding six inches beyond the finger can replace the banjo splint (see Fig 20)

SPLINTAGE.—Splintage must be used whenever indicated. The cock up splint to maintain the wrist at a 25° to 30° dorsiflexion is frequently indicated. It will be noticed that improvement in the flexion of the fingers follows placing the wrist in this position

OPERATION —In a few obstinate cases of ankylosis of the finger joints due to contraction of the capsule and adhesions, I have had some excellent results by the following simple operation

A small blade, sharp knife is inserted through the skin on either lateral aspect of the affected joint and a vertical incision is made through the joint capsule. As attempted flexion of the finger is made one can usually feel the tense bands of adhesions or foreshortened ligaments with the knife blade, and these are incised The finger is then flexed gently and gradually until full flexion is obtained Next Mock s finger calipers are applied through the skin and into the bony phalanx just distal to this joint. The ring of the calipers is fastened to the loop of a banjo splint by a rubber band to maintain traction which separates the articular surface and tends to pull the vertical incision in the capsule into an elongated or longitudinal line Early passive and after a few days active motion can be utilized in the affected finger even while the traction is maintained This method is especially applicable to an obstinate stiff joint in a single finger

Flexor contractions usually follow nerve injuries The stiffened joints which develop in these contractures should be treated as just outlined above except that the method of traction must be reversed

MISCELLANEOUS CONDITIONS

One or more of the joints of the wrist, hand and finger are often involved in nerve injuries causing the so-called clawhand, in von Volkmann s ischemic paralysis occasionally in Dupuytren s contracture of the fascia of the palm and following distant injuries especially elbow joint injuries and in the lower third of the humerus which involve the musculospiral nerve and in injuries to the brachial plexus

There are certain operative procedures that are indicated in some

entirely over the lower abdomen and pelvis Following the application of heat firm stroking and kneading massage should be instituted At first the surgeon should daily assist the patient in a certain amount of active exercise and as soon as it is safe the patient must be encouraged to continue and increase active exercise. The amount and dosage of these methods must be increased daily

SUPPURATIVE CONDITIONS

In suppurative conditions of the hip joint the patient usually becomes cachectic and anemic. While the above local administration of physical therapy will help restore function to a certain extent in the hip joint general physical therapy in the nature of quartz light violet rays combined with cod liver oil is extremely important and should never be neglected. If the patient can be moved outdoors in the sunshine heliotherapy is definitely indicated.

DEFORMITIES RESULTING FROM FIBROUS FIXATION

Deformities which are the result of fibrous fixation require traction occasionally splintage and heat, massage and active exercise The usual deformity is flexion of the hip joint and increased lordosis of the lumbar spine. Often the flexion deformity is accompanied with marked contraction of the adductor muscles near their origin.

In younger people subcutaneous incision of the contracted adductor muscles followed by manipulation of the hip joint under anesthesia, and followed immediately by prolonged heat massage and assisted active and active exercises will often result in restoration of function If the condition is the result of septic processes it is questionable whether this procedure should be followed Certainly several months should elapse before it is attempted During the waiting period prevention of further deformity is indicated

In older individuals it is much wiser to resort to slow traction on the lower leg to overcome the flexion deformity accompanied with daily physical therapy treatments as already outlined. Even in old people it may be necessary to sever the adductor muscles subcutaneously near their origin before their flexion deformity can be overcome

The opposite or normal hip should be exercised daily by flexing the thigh completely on the abdomen in order to help overcome the lordosis deformity In the case of old fractures or in old people, no undue force must be used in this manipulative procedure, even of the well hip because of danger of refracture or of fracturing the neck of the femur in the uninjured hip

ANKYLOSIS AND OLD DISLOCATIONS

Bony ankylosis of the hip joint and old hip dislocations frequently require operative procedure In the young person arthroplasty of the

deformity in the neck of the femur was definitely overcome By the use of this apparatus early mobilization of the hip joint can start

When suppurative processes develop in the hip joint following injury they must be opened and drained A drainage tube placed in the hip joint causes erosion of the joint cartilage and invariably leads to ankylosis. Therefore, if drainage is necessary, a tube or Penrose drain can be sutured to the cut capsule above and below, thus forming a tunnel A slight pull upon these drains will keep the capsule wound wide open Traction on the lower leg is essential to overcome the abduction position of the thigh and the flexed position of the knee which practically always accompany this condition. The traction

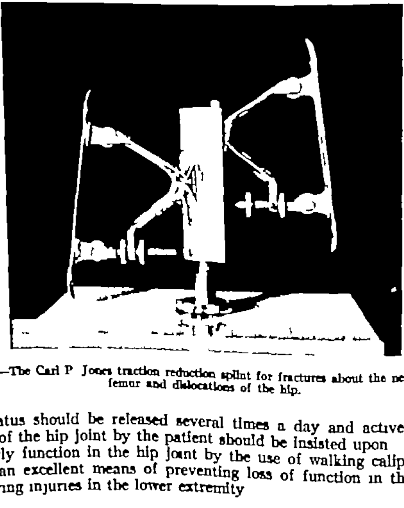

FIG. 15—The Carl P Jones traction reduction splint for fractures about the neck of the femur and dislocations of the hip.

apparatus should be released several times a day and active movement of the hip joint by the patient should be insisted upon

Early function in the hip joint by the use of walking calipers has been an excellent means of preventing loss of function in this joint following injuries in the lower extremity

Restoration of Function.—If prolonged immobilization by the body cast has been necessary just as soon as the cast is removed physical therapy should start. These patients are usually still bed ridden Heat can be applied to the hip joint in the form of large fomentations, an infra red lamp or a large electric baker which fits

during the last 14 months I have had two cases of ununited fractures of the neck of the femur—one in a man of 26 and the other in a man of 40 years of age I operated on both of these patients performing a modified Bracket operation. Good union and 80 per cent function in one case and 60 per cent function in the other were obtained chiefly by the early and persistent use of physical therapy methods as already outlined

FIG. 6 —Same as Fig. 6a following two weeks of heavy skeletal traction. The head is pulled down almost to the level of the acetabulum. (The acetabulum is completely filled with a fibrocartilaginous growth.)

hip may be justified In older individuals this procedure is question able If the ankylosis is in a badly deformed position transtrochanteric or subtrochanteric osteotomies may be considered (Figs 26a, 26b 26c)

UNUNITED FRACTURES OF NECK OF FEMUR

Ununited fractures of the neck of the femur in old individuals are not uncommon, but they are rare in young individuals Nevertheless

FIG. 26A.—Author case f old dislocation f the hip, six months standing, in a man 55 years f age

Knee

Causes of Loss of Function.—Loss of function in the knee joint accounts for a large percentage of the handicapped people in civilian life Lying as a pivotal point between the large thigh bone and the large bones of the lower extremity it is practically always involved whenever a fracture occurs either above or below the knee

FRACTURES OF KNEE

Longitudinal fractures through the head of the tibia directly into the knee joint and fractures of either the lateral or medial condyles of the tibia T" fractures through the condyles of the femur fractures of the head of the fibula and the fractured patella are the most frequent direct types of fracture deranging the knee joint. Fractures of the patella may be accompanied by a direct injury to the synovia and capsule and the interior of the knee joint or may indirectly affect the function of this joint. Within the knee joint proper fracture of the tibial spine is the commonest type of disabling fracture Occasional sprain fractures with the tearing off of one or more of the attachments of the crucial ligaments occur The usual example of this type of sprain fracture is the tearing away of a part of the articular surface of the tibia in the vicinity of the attachment of the anterior crucial ligament

STRAINS OF KNEE

Strains of the knee are not at all uncommon They differ from sprains only in the degree of force and length of time of action of force upon the knee joint. Strains of the knee may be followed by a synovitis but it is never as persistent a type as is seen in sprains neither does it tend to recur Failure to relieve the synovitis in strained conditions may lead to a thickening of the synovia, hypertrophy of the villi of the synovia and calcification. Heavy individuals often complain that their knees are weak. Repeated slight strains are not uncommon in such people. The slight frequently recurring synovitis may gradually lead to thickening of the synovia and a form of traumatic synarthrosis This may or may not be painful Such individuals especially heavy women complain of cracking and grating noises in their knee joints, particularly when climbing stairs. This form of arthritis is more probably due to this repeated slight trauma than to toxic causes otherwise why does it seem limited to heavy individuals and especially to heavy women who have a weaker protective mechanism about the knee joint?

Functional Position —When partial or complete ankylosis of the hip joint is threatened or inevitable, one should place the thigh in the position which will tend to give the best function As already indicated the commonest deformity of the hip is flexion and adduction. When ankylosis is inevitable effort should be made to place the thigh in an extended slightly abducted position with slight outward rotation

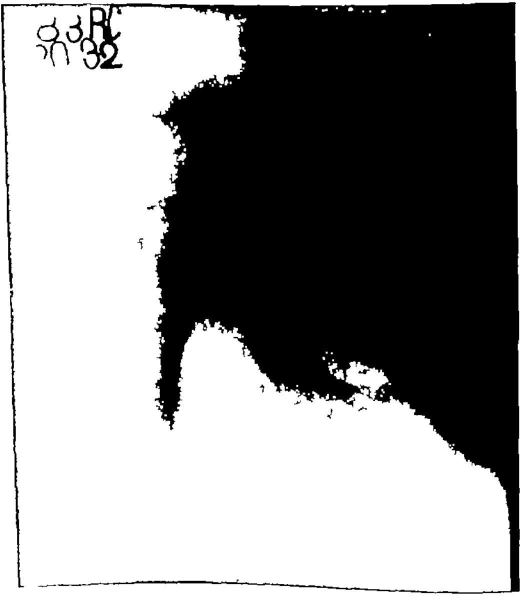

Fig. 10c—Same case following open reduction of the old dislocation. (The fibrocartilaginous exudate was completely reamed out of the acetabulum before this dislocation could be overcome.)

INJURIES TO SEMILUNAR CARTILAGES

Injuries to the semilunar cartilages can become extremely disabling and may account for many of the permanent disabilities within this joint Displacement or fracture of the external semilunar cartilage is comparatively rare and does not give the marked symptoms usually found when the internal cartilage is involved. Locking of the knee seldom occurs. The commonest sign is a catch and then a sudden jerk or slipping just before complete extension of the knee is accomplished This catch or slipping is referred by the patient to the external aspect of the knee and the surgeon, with his hand over this area, can usually feel the condition Certain phlegmatic individuals may ignore the condition altogether but others especially if compensation is involved worry over such an injury often making operative procedure compulsory

Displacement or fracture of the internal semilunar cartilage is a disabling condition It is usually accompanied by marked effusion into the joint pain and a locking of the joint. These symptoms may subside and may not recur for months or years I seldom operate after the first attack if it shows signs of subsiding. Recurring attacks of synovitis pain over the internal semilunar cartilage or recurrence of locking makes operative procedure justifiable and often necessary

JOINT MICE IN KNEE JOINT

Osteochondritis dissecans and joint mice are practically as common in the knee joint as in the elbow joint. They frequently follow trauma or may be a late condition in the synarthrosis described above or may follow a definite arthritis of this joint Rice bodies tend to form in fringes of the torn synovia Hypertrophy of the synovial villi followed by calcification is frequently the source of these joint mice When present they can simulate dislocations of the semilunar cartilages and when trauma reveals the first manifestation of their presence differential diagnosis from injured cartilage is difficult. An x ray usually shows their presence whereas an x ray seldom shows a dislocated cartilage. It is important to make the differential diagnosis because in the operative procedure the knee joint must be more thoroughly exposed for removal of joint mice than is usually necessary for cartilage operation

DISLOCATIONS OF KNEE

Dislocations of the knee are more frequent than formerly due to the extreme violence of many present-day accidents especially automobile accidents There are three varieties the dislocation being named according to the displacement of the tibia, as follows (a) forward dislocation (b) backward dislocation (c) lateral dislocation

These conditions of course are totally disabling unless they are fully reduced The loss of function which follows a dislocation is due

SPRAINS OF KNEE

Sprains of the knee are second only to fractures as a cause of loss of function in the knee joint. Tearing of the internal lateral ligament is the commonest form of sprain If it tears at a point on a level with or above the internal condyle of the femur, the internal semilunar cartilage is rarely involved, but a tear below this level is usually accompanied with a displacement or a fracture of the internal semilunar cartilage Such a condition is accompanied by a marked synovitis, and if the semilunar cartilage has been involved, there is usually a recurrence of the synovitis

Sprain of the external lateral ligament is not a frequent occurrence It is not usually accompanied by a synovitis, neither is the external semilunar cartilage damaged by this sprain

Sprains of the crucial ligaments usually a stretching or a complete rupture of one or both may occur without any evidence of fracture. The anterior crucial ligament is more frequently damaged than the posterior The anterior crucial ligament is attached to the internal prominence of the spine of the tibia and the external semilunar cartilage is attached to both the ligament and the spine of the tibia Frequently in injuries of the anterior crucial ligament the spine of the tibia is torn off and displacement of the external semilunar cartilage occurs

Stretching or rupture of the posterior crucial ligament alone is very rare Cubbins of Chicago is of the opinion that this injury is commoner than is supposed and that it is frequently overlooked. Damage to this ligament usually occurs in severe dislocations of the knee joint.

In the presence of a persistent synovitis with pain on pressure over the region of one or both semilunar cartilages, a diagnosis of injury of the semilunars is frequently made The increased anteroposterior and lateral movements of the knee joint are not evident because of the persistent effusion and swelling In many cases the semilunars are operated upon and removed The escape of the effusion at the time of the operation and the prolonged rest following the operation alleviate the swollen condition of this joint. When the patient is allowed up and movements start, the loose knee joint is discovered. Often the patient attributes the condition to the previous operative procedure whereas it is due to the undiagnosed injury to the crucial ligaments usually the anterior

SPRAIN FRACTURES OF KNEE

Sprain fractures have already been referred to In a sprain of the internal lateral ligament a chip fracture at the point of its attachment to the femur is frequently revealed by the roentgenogram. Likewise the x ray may show a chip fracture from the head of the fibula in sprains of the external lateral ligament.

PENETRATING WOUNDS OF KNEE

Penetrating wounds of the knee joint are common. When a foreign body has penetrated the knee joint it must be removed. If the penetrating body is a piece of steel or a bullet, removal can usually be done at once If the material is dirty and infection is liable to follow early removal must be followed by adequate drainage for possible infection If infection has already developed immediate drainage with later removal of the foreign body may be preferable

External wounds of the knee joint for example severe lacerations and severe burns may result in a complete loss of function due to scar-tissue formation

DISTANT INJURIES WHICH AFFECT KNEE

Distant injuries may account for loss of function in this joint It is not uncommon to see a stiff flexed knee joint following an amputation in the upper third of the leg Fractures in the extremity distant from the knee joint can easily result in a stiff knee due to contractures and fibrosis. Atrophy of the strong muscles and aponeurosis surrounding the knee joint due to prolonged immobilization of the extremity prolonged disuse cord injuries or other causes for paralysis may frequently result in definite loss of function in this joint Following fractures in the foot, a marked flatfoot condition may develop Following a prolonged illness after which the patient is allowed out of bed to walk around in carpet slippers while the muscles are still in a weakened condition may result in a flatfoot. As one grows older he may develop a flatfoot. This condition of flatfoot frequently causes derangements of the knee joint which may become very disabling

Prevention of Loss of Function.—In addition to the preventive measures already referred to in remarks concerning loss of function certain general principles must be observed in all knee joint injuries if loss of function is to be prevented in many of them

Careful Diagnosis —Diagnosing the injury as an *internal derangement of the knee joint* allowing the patient to continue to use that joint when careful study and observation might reveal *the definite nature of the injury* thereby allowing institution of proper early treatment accounts for a great many cases of prolonged disability and occasionally a permanent loss of function.

Accurate Diagnosis of Each Injury —Multiplicity of injuries which may follow severe knee-joint traumas require in this joint as in the shoulder and elbow joints accurate diagnosis of each injury and the adaptation of that line of treatment which will give the greatest protection to ultimate function

to the tearing of the lateral ligaments and to the stretching or rupture of internal crucial ligaments Injuries to the popliteal vessels or nerves must always be kept in mind Pressure upon the popliteal artery if the dislocation is left reduced may cause gangrene In one of my cases of dislocation of the knee there was immediate evidence of injury to the anterior tibial nerve and within a few hours a cold blanched lower extremity was noted In spite of early reduction of the posterior dislocation, the lower extremity became gangrenous An amputation was finally necessary Immediately following the amputation Dr Hirsch pathologist at St Luke s Hospital, dissected out the structures in the popliteal space There was no evidence of external injury to the popliteal artery yet the intima of this artery had been torn completely loose and washed downward for approximately two inches at which point it completely blocked the lumen of the artery A considerable thrombosis formed above this point of block

TRAUMATIC ARTHRITIS OF KNEE

Traumatic arthritis has already been mentioned It can easily be a late development in knee-joint trauma Contusion of the joint cartilage cannot be recognized in early x ray pictures and yet films taken several months later may show definite evidence of bony proliferation. the picture of an osteo-arthritis This condition may progress until the joint function is completely destroyed when ankylosis will follow This type of arthritis is usually due to a combination of the trauma plus invasion of the knee joint by infection Frequently traumatic arthritis is a late development from injuries to the synovia. The synovial fringes may be contused by impinging between the joint surfaces or there may be tears and hemorrhage into the fat pads, especially the infrapatellar pads and the fat contained within the ligamentum mucosum. Contusion of a fat pad followed by hemorrhage and swelling followed by fibrous and frequently calcareous changes, may be the source of the arthritis and may eventually result in the formation of joint mice as described above.

The knee joint is not an infrequent site for purulent arthritis especially in children and young adults. There is often a history of slight trauma followed by an invasion of the joint from pyogenic organisms within the body and by abscess formation Due to the firm tissues surrounding this joint, too many cases of purulent arthritis go undiagnosed until the x-ray shows definite damage to the joint cartilage and surrounding bone. Loss of joint function frequently follows this condition. Early diagnosis adequate drainage, *the avoidance of drainage tubes within the joint* and early mobilization of the joint after drainage are the only means which will prevent almost complete loss of function in the knee joint following a purulent arthritis

their feet or if this is impossible to use walking callipers When callipers are impractical the patient should use crutches Weight bearing as already indicated is an excellent preventive measure when mobilization of the joint is contraindicated.

EARLY DRAINAGE.—Extensive swellings of the knee joint from effu sion or hematoma should be relieved as rapidly as possible Rest heat alternating heat and cold and occasionally massage may be suffi cient However in the more severe effusions aspiration and (if it recurs) repeated aspiration are far better than to allow the overstretch ing of the capsule over a period of weeks When there is a hemo-arthrosis early aspiration will frequently prevent blood-clot forma tion with subsequent organization and fibrosis and often traumatic arthritis of the various types already described.

The early diagnosis of pus within the joint and early drainage before great damage is done to the joint cartilages or adjacent bones is absolutely essential if complete loss of function is to be avoided.

TRACTION —Traction thereby separating the joint surfaces is equally as important in the knee joint in many conditions as in the joints already described Whenever possible this traction should be so arranged that it can be released for active knee-joint movement at least twice a day In the majority of cases where traction is necessary for fractures in the femur and adhesive traction bands are used across the knee joint, release of the traction for knee-joint movement is im possible For this reason skeletal traction through the condyles of the femur leaving the knee joint free to be moved is preferable

EARLY TREATMENT —The earlier heat massage and active exer cises can start in an injured knee joint (depending upon the nature of the trauma) the surer are the possibilities of restoration of function

MOBILIZATION OF PATELLA.—The importance of mobilizing the pa tella in practically all knee-joint injuries and in all knee joints where prolonged immobilization is necessary or has been instituted, must be emphasized and reemphasized The tendency of the patella to become adherent to the infrapatellar tissues the fibrosis of the bursae about the patella, and the contraction of the patellar ligament, is the commonest cause of stiff knee joint Even when massage and exercise of the knee joint proper are impossible that line of treatment should be adopted which leaves the patella exposed for massage and frequent lateral and up-and-down movements Surgeons have learned the im portance of keeping the foot elevated at a right angle to prevent foot drop and the importance of placing the arm in the case of wristdrop in a cock-up splint they are more and more learning the importance of treating the injured shoulder in the abducted elevated position but the importance of the mobilization of the patella, which falls in the same preventive category is not appreciated or is too frequently

EARLY FUNCTION.—Prior to the War the majority of us unable to recognize many of these obscure injuries were satisfied with the diagnosis of internal derangement or sprain of the knee joint and resorted to the time-honored treatment of immobilizing the knee in a plaster cast for a period of several weeks or months. Fortunately in the younger people nature was kind and restored full function after such treatment. In older individuals, however, prolonged immobilization usually resulted in a stiff or partially stiff knee joint.

It is noteworthy that in the knee joint synarthrosis, thickening of the capsule, contraction of the ligaments, and adhesions within the joint are not so common following prolonged immobilization as is the case in joints of the upper extremity. The exception to this is when the patient is bedridden and the knee is immobilized, especially in a cast. In this group, soft tissue stiffness of the knee joint is common. Complete immobilization of the joints in the upper extremity is practically always associated with complete disuse, whereas complete immobilization of the knee in a splint or plaster cast, provided the patient is not bedridden, is always accompanied with a certain amount of use. Even though such a patient walks on crutches, the injured lower extremity is swinging, is being lifted to an elevated position when the patient sits down, and is otherwise moved. A patient who has his knee immobilized and yet is allowed to walk upon that extremity is receiving more movement and exercise in the knee joint than we usually suspect. Undoubtedly it is this limited exercise and limited continuation of function that prevents more severe damage in prolonged immobilization of the knee joint. We have in this example an excellent criterion for the functional treatment of all joints when immobilization of either the upper or lower extremity is necessary. Active movements of the upper extremity and movements and weight bearing in the lower extremity are essential if loss of function in their various joints is to be prevented. Patients who have the knee joint encased in a plaster cast while the joint is still somewhat swollen frequently complain that the cast is loose after three or four weeks. If they only knew it, this is a direct gift from the gods, for it allows a certain amount of motion which is greatly to be desired.

EARLY MASSAGE.—As far as possible all injuries of the knee joint should be treated by early massage. This is especially true in fractures of the lower extremity which require the patient to be bedridden. A cast extending across the knee joint in a bedridden patient always results in a stiff knee, which is overcome only after weeks of prolonged effort. In older individuals it is frequently never overcome.

WALKING.—There are severe injuries within the knee joint and severe injuries in the lower extremity that require prolonged immobilization, often with a cast. Loss of function in the knee joint can be prevented or greatly reduced by allowing such patients to walk upon

For the last five years it has been my custom *never to apply a posterior splint to the knee joint following this operation* The case is usually operated upon in the morning In the afternoon I visit the patient and show him the loose padded bandage which has been applied to the knee joint and instruct him that he is to move the knee as far as possible within this bandage The patient can be trusted not to move it beyond the pain point. Each day I instruct him to move the knee more and more and by the time the stitches are removed on the ninth or tenth day the majority of these cases have from 25 to 50 per cent knee-joint movement

FIG 27 —*A* case of fracture-dislocation of the internal semilunar cartilage two weeks following operation. *B* same case as Fig. 27 a, showing the amount of knee function two weeks after operation Active movements of the knee joint were started immediately after the operation resulting in almost complete function at the end of two weeks.

neglected In all cases of fractured patella which have been operated upon, daily, and better, twice daily, exercise of the patella is of prime importance Most of us know this fact but, let it be said to our shame few of us take the time every day to insist upon it

Treatment.—In intra articular injuries there are certain ones which demand mobilization treatment and others which require prolonged immobilization

SEMILUNAR CARTILAGE INJURIES

Synovitis

In semilunar cartilage injuries correction of the locking if present is immediately necessary, followed by relief of the marked synovial effusion usually by aspiration and followed by a period of rest of the joint for two or three weeks When seen early after the injury these cases should be hospitalized and rest should be obtained by keeping the patient in bed. Large hot fomentations applied to the knee with or without aspiration of the effusion furnish sufficient immobilization After three or four days the patient should be allowed very slight active movements while in bed If there is a tendency for the effusion to recur necessitating reäspiration the period of rest in bed may be prolonged, or after two weeks the patient may be allowed to walk on the extremity provided the knee joint is strapped or bandaged tightly The walking and the limited motion allowed within the strapping are sufficient exercise to prevent fibrosis

In cases seen late with effusion still present aspiration of the effusion followed by tight strapping or bandaging and allowing the patient to walk is usually sufficient. In the latter case aspiration is frequently done in the office. The same meticulous asepsis relative to sterilizing the needle and preparing the field for aspiration must be followed in the office as is observed in the operating room If as too frequently happens this is impossible the aspiration of the knee or any other joint should be a hospital procedure It is well to have this late case report after one week when the bandage or strapping is removed for the administration of heat (diathermy infra-red lamp electric baker hot fomentations local leg bath, or hot whirlpool bath) massage and guided active exercises The same measures may be necessary in the acute case if there is still evidence of pain and some stiffness after he is allowed out of bed.

Operation —Following operations for removal of the semilunar cartilages most authorities on this subject advise splinting for a period of two to six weeks. It is the practice of many surgeons following this operation to apply a plaster cast for a similar period The splinting or cast accounts for many of the cases of partial loss of function so commonly seen following semilunar cartilage operations.

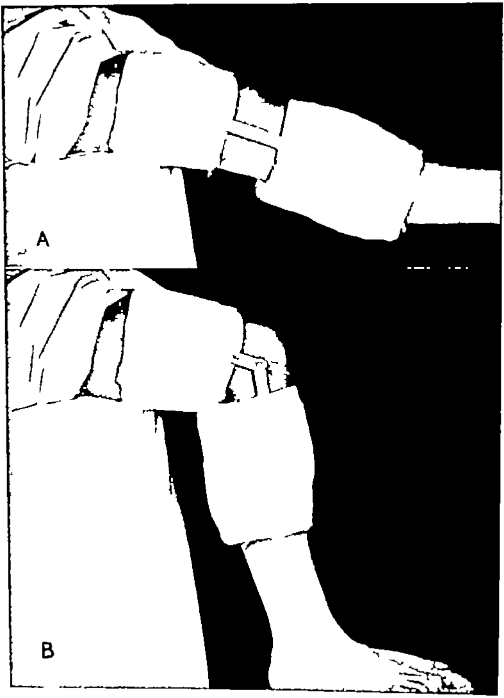

FIG. 18.—*A* hinged plaster of paris cast allowing flexion and extension movements of the knee joint *B* same as Fig. 18, a.

Massage Heat Exercise—Massage of the muscles of the lower leg and of the thigh start early but no massage is given directly over the knee joint until the wound is healed thus preventing the danger of infection The exception to this is the massage given by the surgeon himself when dressing the wound At least two or three times during the first nine days the dressings are removed from the knee and the surgeon, with his hands protected by sterile gloves can swab the entire area of the knee joint with alcohol and massage the popliteal space move the patella and otherwise give a fairly good massage to the joint proper Massage of the upper and lower extremities can be left to the technician After the tenth day when the wound has healed, heat massage and active exercise can be given in increasing doses. By the end of the third week these patients can be discharged usually with 75 to 100 per cent of joint function present (Fig 27) If necessary the physical therapy treatments should be continued until full joint function has been secured This can usually be done after the patient is ambulatory and has left the hospital by having him report either to the surgeon s office or to the physician specializing in physical therapy

This mobilization treatment modified as necessary to meet special cases can be employed in most operative conditions for the removal of joint mice fat pads following synovectomies and similar conditions

In addition to the active motions herein described the surgeon must make sure that free movement of the patella is present or is improving daily

INTRA ARTICULAR INJURIES

There are *intra-articular injuries* which may require prolonged immobilization, viz. stretching or rupture of the crucial ligaments fracture of the tibial spine or of the tibial articular surface with displacement and finally dislocations of the knee joint It is difficult for a surgeon to write of joint trauma without going into too much detail concerning the actual nonoperative and operative treatment of the condition The length of this chapter reminds me that I have already indulged this tendency in other joint conditions The purpose of the chapter is to deal with the prevention and when necessary the restoration of function in these disabling joint traumas

DISLOCATION OF KNEE

Reduction —A dislocation of the knee requires immediate reduction followed by complete rest and immobilization. The crucial and lateral ligaments are always torn Operative procedure for the reduction is not necessary Immediate operative repair of the crucial or lateral ligaments is never indicated. There is often damage of the joint cartilage surfaces when a complete dislocation occurs For this reason after reduction is secured I prefer to keep the patient in bed with a

lost Therefore massage of the thigh and leg muscles and the use of a faradic or sinusoidal current to keep up muscle tone are most definitely indicated during the weeks of immobilization.

Operative Procedure —In the case of undue lateral or antero-posterior movement, I prefer to continue the wearing of the immobilizing appliances for at least six months before considering operative treatment on the crucial ligaments If there is evidence that the disability is due solely to a torn internal lateral ligament with semilunar cartilage displacement earlier operative procedure may be indicated

Physical Therapy —In the case of a partially stiff knee joint after the cast or immobilization appliance is removed, I prefer slow gradual physical therapy methods to overcome the condition rather than forcible manipulation The latter can easily undo all the advantages gained by prolonged immobilization

TORN LIGAMENTS

Immobilization —Torn lateral ligaments and stretched or ruptured crucial ligaments are treated in exactly the same way as described for dislocation of the knee Prolonged immobilization gives good functional results in the majority of these cases Many of the cases which require operative procedure are those in which the diagnosis of damaged ligaments was never made and therefore, the period of treatment was not sufficiently prolonged After the acute symptoms have subsided or after recovery from a semilunar cartilage operation (for many of these have been operated on for this condition) the patient is urged to walk and exercise his knee His complaints of weakness of falling or other queer complaints were ascribed to a neurosis Finally such a patient is referred for reconstructive surgery Complete diagnosis of the original trauma with sufficiently prolonged treatment might have resulted in a cure without the need of surgery

Tears of the lateral ligaments are better treated with the leg in complete extension Tears of the crucial ligaments are better treated with the leg in 15 to 20 of flexion Since it is difficult to determine which of these groups of ligaments has been more severely damaged the dislocation of the knee should be treated with the leg either extended or very slightly flexed If no dislocation has occurred and the nature of the accident was not too severe the extension position is indicated but if a definite diagnosis of torn crucial ligaments is made a position with 10° of flexion is indicated during the period of immobilization The same physical therapy measures outlined for dislocations are indicated in the treatment of these torn ligaments

The anterior crucial ligament is more often stretched or ruptured than the posterior When the lower leg is partly flexed and a sudden force on the outside of the knee or a fall of the body inward causes

Thomas splint and light traction on the lower extremity to keep the joint cartilages slightly separated

SPLINTAGE AND TRACTION —The Thomas splint either is bent at the knee or is padded under the knee to give approximately 10° of flexion In slight flexion the crucial ligaments are more relaxed and even though light traction is maintained for two weeks, these ligaments are not unduly pulled away from their normal locations. There is a tendency for flexion deformity to occur in crucial ligament injuries and this, of course is to be guarded against Let me emphasize that heavy traction is not desired but 15 lb of traction will keep the joint surfaces slightly separated and slight shrugging movements or the slight movement accompanying massage combined with this will prevent arthritis following the damage to joint cartilages Traction and rest in bed furnish likewise the rest and immobilization that are desired and should be kept up for at least two weeks The further advantage of traction treatment as compared with the immediate application of a cast, is the ease with which the accompanying effusion can be treated by heat, hot fomentations, or aspiration if necessary During these two weeks of traction heat massage, and especially manual manipulation of the patella to keep it free and movable, can be administered.

PLASTER CAST —After two weeks of light traction treatment (or longer if the swelling and reaction in the knee have not subsided), immobilization of the knee joint by a plaster cast or a special knee appliance should be instituted with the leg almost completely extended. With the application of the cast the patient can be allowed up on crutches After four to six weeks light weight-bearing may be allowed The immobilization should be continued for approximately 10 weeks If, at the end of that period there is still evidence of undue lateral or anteroposterior movement continued immobilization is indicated but usually at this stage a hinged two piece plaster cast can be utilized or a special hinged knee brace can be worn (Fig 28) The latter is preferable as it can be removed for heat massage, and carefully guided exercises by the surgeon or a trained technician who should always guard against undue lateral or anteroposterior movements Frequently after the removal of the cast the knee joint is fairly stiff

MANIPULATION —The stiffness is often due to a fixed patella To prevent this the front of the cast should be cut out shortly after the cast is applied and the patella massaged and manipulated daily The patient can often be instructed to shrug his muscles and otherwise keep the kneecap movable

The stiffness may be due to contracted muscles Often however the muscles about the joint have become badly atrophied so that the strong muscular protection of the joint against undue movement is

massage and slight active exercises. At the end of five weeks the patient was discharged but was placed in a hotel rather than allowed to return to his home in a distant city Daily he went from his hotel to the physical therapy laboratory where carefully supervised treatment was given. By the end of six weeks, complete extension was allowed and flexion movements were actively performed until the pain point was reached Heat the whirl pool bath massage and walking exercises such as walking up a gradual incline and, later the climbing of very low steps, were gradually added to the treatment After 10 weeks no protective splints or appliances were used. At the end of four months I demonstrated this case before the Chicago

Fig 9.—*A* case f t rn anterior crucial ligament showing the incision f recon struction of the ligament from fascia lata *B* same case as Fig. 9, showing the amount of knee flexion obtained by this patient five months after the operation.

Surgical Society He had 45 of flexion and a perfectly stable knee joint and walked readily without a cane He stepped up on a chair in order to show his knee to the audience In doing this he put the foot of the injured leg on the chair first and raised himself with this leg

It is my opinion that in younger men with many years of active work ahead of them this operation followed by a careful physical therapy régime is indicated when a loose knee joint is the alternative.

a sudden abduction of the tibia with internal rotation the anterior crucial ligament is usually ruptured When the leg is partly flexed and the sudden force causes an adduction of the tibia possibly with external rotation the posterior crucial ligament may be ruptured Usually this force causes a fracture of the internal articular shelf and tuberosity of the tibia and this fracture probably allows sufficient give in the joint to protect the posterior ligament from complete rupture When the leg is almost completely flexed and the foot fixed and a strong inward force is applied at the knee the tibial spine usually fractures the anterior crucial ligament stretches or ruptures, and the external shelf of the tibial articulation may be fractured

These combinations of fractures and ruptures of the crucial ligaments especially the anterior ligament, must always be kept in mind. The x ray is always indicated in knee injuries even of minor degree and thus the fracture is discovered Immobilization and the physical therapy measures described under dislocations are the treatment of choice here If the fractured fragments interfere with joint movement after every effort by closed reduction has been exhausted and after the traumatic reaction in the knee has subsided operative replacement or removal of the obstructing fragment of bone is indicated

Case II —A year ago a patient was referred to me for reconstructive surgery Eight months before he had stepped in a hole small enough to incarcerate his foot, had fallen forward, thus bending the knee and at the same time he had fallen inward due to the falling of a heavy jack used under a locomotive engine against the outside of his knee He had been treated with a cast to the knee for six weeks. Following this he used crutches and attempted to use his knee. Instead of improving he developed weakness, undue lateral and anteroposterior motion, and inability completely to extend his knee. It was more comfortable in a flexed position A hinged knee brace was applied after six months and this enabled him to walk but without it the knee was so unstable that he was crippled. Figure 29 shows a patient following a reconstructive operation which I performed utilizing fascia lata to reconstruct a new anterior crucial ligament which had been partially torn and so stretched that it was useless. This operation is described most completely by Jones the original operation being ascribed to Hey Groves.

The question of prolonged immobilization following this operation was considered but it seemed to me that early function of the knee joint would help strengthen this fascial replacement and cause it to assume ligamentous function. Therefore the patient was placed in bed with the leg in a Thomas splint and the knee flexed about 10 Massage of the leg and thigh muscles, which were atrophied, was started at once the incisions being carefully protected. The patient was instructed to shrug his muscles and after the fourth day the patella was carefully moved laterally to keep it free. This was repeated at each dressing All stitches were out by the end of two weeks and the wounds healed thus allowing more active massage. At this time very slight active motion of the knee joint was permitted At the end of three weeks a posterior splint was applied with very slight flexion and the patient was allowed up on crutches. He reported to the technician for daily heat,

When these fractures occur with little or no displacement a short period of complete immobilization followed by mobilization and physical therapy usually results in excellent function. Great care must be taken to discover comcomitant injuries which may nullify efforts at functional restoration.

I usually keep such patients in bed for one week if there is marked effusion or hemo-arthrosis present. The leg is protected in a Thomas splint and by traction Aspiration is done if necessary As soon as feasible a posterior plaster splint from the mid thigh to the ankle is applied and the patient is allowed up on crutches Massage and movements of the patella are given. After two weeks the splint may be removed for heat, massage and *very slight* active exercises After four weeks more definite slight flexion and extension can be permitted Weight bearing at first aided with crutches can start at the end of six weeks and by the end of eight weeks full weight-bearing and 50 per cent of flexion should be present Physical therapy is continued for another two weeks by which time full function is usually restored

Where there is marked displacement downward with a very definite offset in the articular surface operation is indicated first to replace the fragment and if this is impossible to insert a wedge of autogenous bone which will reconstruct the joint. Following this the line of treatment is carried out as above except that each step is delayed approximately two weeks

Fractures of the head of the fibula are the most frequently overlooked fractures in the body They often occur with Pott s fractures. The latter give very definite signs and symptoms and the x ray is confined to them. The fracture in the head of the fibula is not discovered until the patient s complaint of knee pain and loss of knee function attracts the surgeon s attention usually weeks later Therefore x-rays should always include adjacent joints in fractures of an extremity

Fractures of the patella are one of the commonest causes for loss of knee-joint function Those due to marked contracture of the quadriceps or due to direct injury with little displacement can be treated conservatively Strong fibrous union of the fragments which are even slightly separated seems to give good functional results.

Operative procedure A fractured patella with definite separation of the fragments is better treated by operative procedure The technic will not be discussed except to say that I am securing a good union just as rapidly by the simple procedure of coaptating the fragments and then using mattress sutures of either No 2 chromic catgut or a very small kangaroo gut placed through the patellar tendon periosteum and aponeurotic covering above and below the site of fracture to hold the fragment in position.

FRACTURES

Periarticular articular traumas of the knee joint which require special mention are fractures which extend into the articular surfaces, often resulting in permanent loss of function

A T FRACTURE THROUGH THE CONDYLES usually shows a marked backward displacement of the distal fragment of the femur with separation of the fracture line between the condyles. Occasionally one or the other condyle may be partially rotated As nearly perfect alignment of the condyles as possible is necessary for good function. At least 50 per cent of coaptation of the fractured fragments of the femur is sufficient to give good function. Better approximation than this is, of course, desirable but failure to secure it does not warrant open operative reduction I mention this because I have seen far fewer good results in knee function from operating on this fracture than I have seen when the closed method is used Manipulation, usually with strong traction on a Hawley table or the slower method of skeletal traction, will reduce such fractures The application of the ice-tong type of skeletal traction will tend to squeeze the fractured fragments of the condyles together A Thomas splint with a knee attachment allowing flexion of the lower leg is used and is far preferable to the application of a thigh and leg cast with the necessary immobilization of the knee. A Blake skate or a similar splint fastened to the sole of the foot keeps the foot at right angles and serves even a better purpose To this splint is attached a rope which passes upward to a pulley on the fracture frame located just above the knee, then passes through a second pulley just above the patient s chest and hangs downward from this pulley with a hand loop in the end of the rope. The patient is taught to grasp this rope, and by pulling and relaxing it he lifts and lowers his foot and leg, thereby maintaining a large amount of flexion and extension in the knee (see Fig 2) This can be done without disturbing the fracture position It is applicable to all fractures in the shaft of the femur when skeletal traction is used and is one of the best means of maintaining knee function Combined with it should be massage of the entire leg Any method which will do away with the prolonged immobilization of the knee in extremity fractures with the weeks and weeks of treatment necessary to overcome the resulting stiffness is to be greatly desired

FRACTURES OF THE TIBIAL TUBEROSITIES often extend upward and inward into the joint The fractured fragment is often displaced outward or is accompanied with comminution and a marked downward displacement thus giving a decided offset to the articular table of the tibia. This latter condition usually occurs on the internal aspect of the joint It results in an adduction deformity of the tibia and a rocking unstable knee joint.

He wears his splint when walking and at night for one to four weeks more depending upon the x ray findings the strength of the leg and the progress toward flexion function thus far made

Seldom is any splint or mechanical appliance necessary after 10 to 12 weeks By this time the average patient is able to flex his knee almost to a right angle Further physical therapy is not usually nec essary as the patient has been trained by this time to perform exer cises which will improve function. For most of them return to work is the best form of occupational therapy to use I keep in touch with the patient until he can kneel and sit on his heels both movements showing that function has been restored

Complete loss of the patella occurs rarely in civilian life It may follow severe extensive wounds as a gunshot wound where the knee-cap is shot away or a severe infection with a complete sloughing of the patellar tendon patella, and tissues at the front of the knee or as in one of my cases it may follow a sloughing without evidence of infection

Case III.—Mr H was a railroad case sent to me from Ohio approxi mately one year ago Some eight months previously he sustained a fracture of the patella with separation of the fragments and was operated upon, chromic gut being used to approximate and hold the fragments After a time the fragments separated, he was again operated upon and the frag ments were approximated and held by the use of wire. The first operation was done by a median longitudinal incision and the second, by a U-shaped incision. Nonunion and separation of the fragments again developed and a third operation was performed in which most of the wire was removed although one loop was left attached to the lower fragment. This approach was by a lateral longitudinal incision. He was referred to me for an un united fractured patella. The fragments were separated approximately one inch The patient complained of pain, a sense of weakness in the knee *joint and only about three degrees of flexion movement in the knee. Here* is an important point I did not give sufficient thought to the disturbed cir culation in the tense skin and aponeurotic tissue overlying this patella. I operated, exposing the patella, by a second U shaped incision. The frag ments were freshened along their fractured edge the loop of wire was re moved and then the fragments were drilled and kangaroo gut was inserted through the drill holes, forming two strong mattress sutures approximating and uniting the fragments. The thickened patellar tendon and aponeurosis were then sutured over the fragments with chromic catgut. The wound was closed and the knee immobilized by a posterior plaster splint with the leg in complete extension Within four days the margins of my incision were black and gangrenous and the skin sutures sloughed out The skin flap above the patella retracted exposing the aponeurosis over th patella which was likewise gangrenous and sloughing. In spite of every effort to stimulate cir culation in these flaps all the soft tissues over the patella became gangrenous and either sloughed or were cut away with scissors. The patella itself was finally completely exposed and within a month it was evident that the

After treatment So many different opinions are expressed by authors concerning the after treatment of these fractures that the average reader is often at sea Recently I have seen the stopping of all immobilization at the end of six weeks advocated Jones advocates the wearing of protective splints for as long as six months I believe the various views depend upon the seriousness of the injury, the amount of displacement of the fragments, and the operation

Badly comminuted and markedly displaced fractures probably require longer immobilization than do milder types Fragments maintained in position by wire passed through drill holes have good internal splintage and therefore probably do not require such prolonged external splintage I personally prefer longer external splintage to hardware over the patella.

In the average case—and there are many modifications of this, depending upon the case—I apply a padded posterior splint from the mid-thigh to the ankle immediately after operation

Early massage of the thigh and lower leg muscles without removal of the splint is started within three days

The wound over the patella is dressed every other day after the third day, with gloved hands, chiefly for the purpose of light manual movements of the patella to prevent infra-patellar adhesions. After removal of the stitches, the massage is given over the knee joint and the movements of the patella are increased

After two weeks the posterior splint is removed for massage of the entire thigh leg and knee joint but no movements of the knee are allowed After reapplication of the splint, the patient can be allowed up on crutches, but no weight bearing is permitted

The patient may now be discharged from the hospital, or, if he can afford it, he is kept for further physical therapy treatment. If discharged, arrangements must be made to continue the removal of the splint and massage at least every third day Walking with the injured leg swinging furnishes good exercise

At the end of four weeks, shrugging of the muscles within the splint or during the massage treatments is allowed and very active foot exercises and the swinging of entire leg are started

At the end of six weeks very gentle active exercise is allowed when the splint is removed for massage At first only 2 or 3° of flexion are permitted This amount of flexing and extending is repeated several times and the splint is then replaced. Daily or every other day for another three weeks the patient reports and the amount of flexion and extension exercises is increased until 30 to 40° of flexion are obtained. By this time the patient is walking with the aid of only a cane, or possibly with no assistance.

After eight weeks the patient is allowed to remove his splint several times a day for the application of heat, rubbing the knee, and active exercise He can be trusted not to overflex it and in fact, must often be urged to stand a little pain and flex it more and more.

Such a knee as this incapacitates a man for heavy work It is pos sible that he could carry on many heavy occupations if he wore a cage splint made of leather and side steel braces partially hinged at the knee joint. It is possible that a reconstructive operation might be beneficial in the average case but neither the patient nor the surgeon was willing to risk further incisions in this area of frequent opera tions and disturbed circulation

Physical therapy for the purpose of overcoming muscle atrophy and of securing 10 to 20 of flexion in such a condition of complete loss of the patella offers the best chance of partial function

A DISLOCATION OF THE PATELLA partial is not uncommon but com plete dislocation of the patella is comparatively rare in civilian prac tice The latter is often followed by recurrent dislocations.

For partial dislocation or the first complete dislocation manual re- duction followed by three to six weeks immobilization of the knee in extension is indicated. During this period of immobilization every effort should be made to strengthen the quadriceps and the patellar tendon by removing the immobilization apparatus daily or every other day the leg still being held in complete extension and massage and muscle stimulation being administered by faradism or the sinusoidal current.

In recurrent dislocations the patient should be operated upon Sev eral operative procedures have been described They consist of either increasing the flange on the external condyle of the femur or shortening and fixating the patellar tendons into the antero-internal margin of the tibia or a combination of both The dislocation is usually outward and would undoubtedly occur more frequently were it not for the fact that "the outer margin of the trochlearis surface of the femur acts as the flange of a pulley wheel and so offers resistance to the outward deviation of the patella (Jones)

STIFF KNEE JOINT FOLLOWING INJURY may be either fibrous or bony An x ray is always indicated to differentiate the type of stiffness Fre quently there is a combination of fibrous and bony ankylosis or if the treatment of the stiff condition is too strenuous the fibrous ankylosis may be changed into a partial or complete bony ankylosis

Following the treatment of fractures in the upper extremity in which the knee has been immobilized and the extremity completely out of use for weeks and months the fibrous stiffness involves fibrosis of atrophied muscles contracted fibrotic changes in the patellar liga ment with fibrous adhesions in the infrapatellar space contracted liga ments and capsules agglutination of the surfaces of the bursa with fibrous changes and agglutination or thickening of the synovia.

Frequently the surgeon is tempted to hasten function in such a knee joint by forcible manipulation The atrophied fibrosed tissues have lost their normal elasticity and will therefore tear rather than give

fragments of the patella were dead and were simply two shriveled foreign bodies lying loosely within the wound Finally during the dressings the fragments of the patella were lifted from the wound even without being cut away In other words the blood supply had been so disturbed that without any evidence of infection gangrene of the soft tissues and of the patella at the front of the knee developed and when all were finally trimmed away we had a knee joint covered by thick fibrous infrapatellar tissue, the patella completely gone and the patellar tendon absent a distance of five inches, a large raw area filling in by granulation tissue and occupying a space of some four inches in length and three inches in width over the anterior aspect of the knee After the patella had been removed this area filled in rapidly with granulation tissue and the skin grew in from the margins so that a skin graft was not necessary The patella was replaced by thick fibrous tissue Heat massage and exercise of the lower extremity

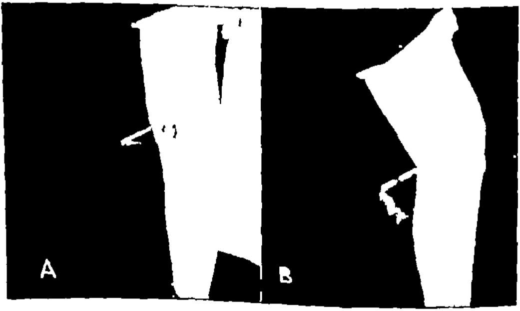

FIG. 30.—*A* complete loss of patella *B* amount of knee flexion secured by patient in Fig 30, a.

were persisted in during and after the healing period. The knee was protected for a time by a cage splint, but as long as this was worn the atrophy of the quadriceps and other muscles about the knee joint persisted Finally all knee splintage was removed and the patient was instructed to walk and use the leg as much as possible. I saw this patient a month ago or some eight months after the wound had completely healed He had approximately 10 of flexion at the knee He had good strength in the leg for walking on level surfaces. If he stepped on a stone or other object on the ground the knee seemed weak and he had a tendency to fall. His greatest complaint was of weakness on attempting to climb stairs normally He could go up two steps at a time provided there was a banister to which he could hold and help pull himself up (Fig. 30)

In some of these crushing injuries the quadriceps muscle and ten dons may have been so damaged and the scar tissue may so involve the capsule and ligaments that a stiff knee joint is inevitable. Here judgment must be used relative to the length of the physical therapy treatment. It is silly to prolong massage and attempted flexion and extension exercises when the very nature of the injury and the associated resulting conditions within and about the knee joint mean that a stiff knee will result.

Thick fibrous pads within the capsule and within the joint proper seldom yield to forcible manipulation under anesthesia Personally I have seen so many disastrous results in marked fibrous ankylosis following forcible manipulation under anesthesia that I do not believe description of the method is indicated here. Physical therapy heat, massage and assisted active and active exercises should be per sisted in daily as described above, as long as there is hope of im provement.

Mechanical traction and slow forceful mechanical flexion by means of various types of apparatus are often helpful in this type of knee joint. In addition to the flexion traction described above one may apply gradual forcible flexion by means of turnscrews fastened into a cast applied around the thigh and a second cast applied around the lower leg and foot. Another method is applying a cast to the entire lower extremity and bivalving it at the knee cutting out con siderable distance of the cast in the popliteal space Wedges are then gradually placed between the bivalved margins of the cast over the patella. The gradual separation of these margins causes knee-joint flexion.

Jones describes Turner s appliance for this gradual forcible flexion thus A plaster of paris cast well padded is applied over the thigh, and a second well padded cast is applied over the foot and lower leg leaving the knee joint exposed. Turner s appliance consists of an instrument that resembles ice tongs but with the distal prongs elongated into strong bands that can be incorporated into the lateral or medial sides of the above mentioned plaster casts A turnscrew rod joins the opposite arms of the ice tongs The handle of the turn screw points upward toward the patient. By increasing or decreasing the distance between the proximal ends of the arms by revolving the turnscrew the patient can cause a certain amount of flexion or ex tension through an activating force carried to the distal arms encased in the casts. This appliance may be attached to one side of the cast but two appliances attached on either side give more even force (Fig 31)

THE STIFF KNEE JOINT MAY BE FIXED IN A FLEXION POSITION This is far more disabling than a stiff knee joint in the extension position The same methods of physical therapy as are used in fibrous ankylosis are required to overcome the condition. Traction applied for the

when forcible manipulation is applied A marked traumatic reaction develops in the joint and practically always increases the disability The swollen, acutely traumatized knee is entirely too painful to tolerate movement The effusion and hemorrhage that accompany the swelling predisposes to more fibrosis Even if some flexion is obtained the atrophied fibrosed muscles and the contracted thickened, weakened ligaments lack the power and function to maintain this flexion.

PHYSICAL THERAPY —Prolonged physical therapy offers far greater hope for restoration of function than does any other treatment.

If there is no active infection but a swollen somewhat painful knee is present, diathermy is one of the best means of relieving this condition If possible it should be immediately followed by massage and very slight assisted exercises

Heat —The application of various forms of heat, followed by increasing doses of massage (at first stroking but soon changed into a kneading or effleurage and especially aimed at loosening up the adhesions about the patella) and by assisted active and active exercises, should be given daily

Exercises —Exercises which are performed by the patient are far better than passive exercises The latter are soon changed into efforts at flexion manipulation by the surgeon or technician and are frequently carried beyond the pain point followed by a traumatic reaction which tends to undo the advantages thus far gained by physical therapy After four or five weeks of treatment the surgeon may attempt gentle but somewhat forcible flexion manipulations once or twice a week. By this time he knows the patient and knows how much pain he can stand or how much he assumes complaint of the pain Never however should such forcible manipulation be carried to the point of tearing fibrosed tissues

Splints and Weights —The application of mechanical means to secure flexion may be adopted provided there are no traumatic reactions within the joint. For example the thigh may be suspended in a Thomas splint at a 45 to a 60 angle. A hinged knee piece may be applied to the Thomas splint just below the knee and the leg supported in this Weights may then be attached either directly to the leg or to the end of the hinged arm of the Thomas splint after the leg is bound to this arm and by means of the weights slow gradual flexion may be obtained. By the use of pulleys and weights other forms of flexion traction may be applied. This method must be observed carefully to prevent traumatic reaction within the knee joint and should always be accompanied by massage and periods of active exercise, especially extending and flexing the leg to maintain the amount of movement thus far gained. Some of the appliances described later may likewise be used

FIBROUS ANKYLOSIS may follow severe crushing injuries of the knee joint, intra-articular injuries and operations within the knee joint.

eral fibrous bands not sufficiently foreshortened or not strong enough to give the picture of stiff knee described above

Every surgeon interested in joint trauma should obtain the little book on manipulative surgery written by A. G T Fisher In this book the author describes the indications and methods for manipulation in the knee joint

Following a few less serious injuries to joints pain and slight swelling and especially pain on certain movements, will persist. These patients are frequently classed as neurotic because the physical examination is negative Usually such a joint is the seat of a contusion often accompanying a complete or partial luxation a sprain or a contusion of the soft parts over the joint The original trauma has been relieved and the surgeon becomes disgusted with his patient for still complaining of pain These obscure conditions are usually the result of adhesions in or about the joint. We expect scar tissue that is a fibrosis in lacerations and open wounds which we can see but we seem to overlook the fact that contused lacerated soft parts below the surface undergo a similar fibrosis

Manipulative Surgery —Manipulative surgery in these cases offers splendid results. Careful study of such a joint will reveal the location of the adhesions first by the point of pain on movement second by a definite point of tenderness and third by a certain limitation of motion in some one direction which is constant. Manipulation usually with the patient awake, aimed at the breaking of these adhesions and the overcoming of the restricted motion, is the first essential followed by daily movements of the joint to its full limit in all directions to prevent the reforming of adhesions. Physical therapy following manipulation is essential in most cases

Bony ankylosis is common Intra-articular injuries followed by a septic infection within this joint, usually result in bony ankylosis. Failure to make an incision adequate for drainage of the joint, the introduction of drainage tubes within the joint, and immobilization of the joint by plaster splint or cast are more often the causes of bony ankylosis than is the invading organism. The importance of traction with daily mobilization cannot be too often emphasized

Injuries which cause damage of the cartilages within the knee joint are frequently followed by bone-cell proliferation and a joint synostosis.

Occasionally bony ankylosis is due to a displaced fragment of a fracture with malunion the fragment acting as a mechanical bony obstruction to joint movement.

Operative Procedure.—Operative treatment of these conditions must be considered In the last-described condition the bony obstruction can often be removed with a good functional result following

purpose of the gradual, forcible increase of extension is usually indicated

The hinged appliance with the upper and lower arms of the appliance connected by a turnscrew can be firmly attached to the posterior aspect of the thigh and leg and then, by the gradual turning of the screw the amount of extension can be forcibly increased.

Whenever gradual, forcible flexion or extension devices are used, they should be removed frequently for inspection of the joint to ascertain if a traumatic reaction has followed these maneuvers, or to ascertain if the knee is gradually returning to its original fixed position If the amount of movement gained by gradual forcible flexion or extension is lost after removal of the appliance it usually indicates a traumatic reaction When this is present mechanical force should be abandoned for the slower but surer methods of physical therapy

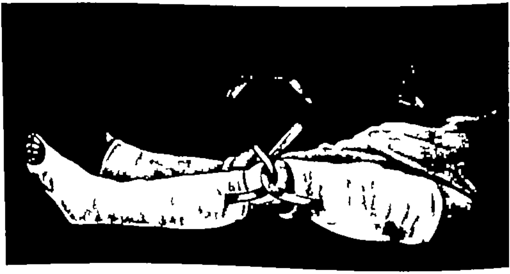

FIG. 3.—Turner's appliance fo gradual forcible flexion of the knee (From Sir Robert Jones' "Orthopedic Surgery of Injuries.")

Frequently following injuries to the knee joint usually of not so serious a nature and frequently following operations as for the removal of semilunar cartilages the patient will complain of a certain amount of *stiffness within the knee joint* or of pain when flexion or extension movement passes a certain point or of a sense of slight locking sudden giving or jerking sensations within the knee joint on movement. Frequently these are not noticed when he is around on the leg during the day but after retiring when the leg is relaxed he will notice these sensations within the knee joint and they will usually be followed by pain.

Practically always the above symptoms are associated with *adhesions within the knee joint* These are usually single adhesions or sev

Physical therapy is indicated in these cases for the purpose of over coming muscular atrophy and maintaining the strength of the quadri ceps muscle This can be accomplished by massage leg exercises, and faradism to the quadriceps

POSITIONS OF FUNCTION —When, following knee-joint trauma, loss of function is threatened or inevitable, the surgeon must guard against faulty positions of stiffening and make sure that when the patient does recover he will have the greatest possible usefulness in the dam aged extremity

I recently talked with a number of orthopedic surgeons concerning the best position of ankylosis of the knee joint. Several felt that the leg was most useful when akylosed at approximately a 10 flexion angle A few others preferred full extension as the best position of function when complete ankylosis was inevitable.

In working men especially when they must be on their feet all day and considerable walking is involved I believe the full extension posi tion gives more strength and causes less backache and tiredness in the lumbar region and groins. The slightly flexed position makes the anky losis less apparent and probably is more comfortable and more useful for the sedentary worker

The tendency for certain deformities in the knee joint to develop during long periods of immobilization must be guarded against.

As the knee joint is stiffening following severe trauma there is a tendency for an undue flexion position to develop A flexion ankylosis beyond a 10 to a 15° angle is extremely disabling

A genu hyperextension or backward angulation of the knee joint is prone to develop during a long period of rest in bed in lower extrem ity injuries Frequent change of position of the knees and especially flexion and extension exercises are the best means of preventing this deformity When this is impossible a posterior splint or a pad in the popliteal space is always indicated. In placing the lower extremity in a cast, it is better to have a slight degree of flexion present to avoid this danger of hyperextension. When the nature of a trauma calls for a complete extension of the lower leg the popliteal space should always be padded to prevent hyperextension.

The *concomitant injuries of other joints* in the lower extremity must always be borne in mind in the surgery of trauma. Protection of func tion in the hip and ankle joint while treating a traumatized knee joint is imperative The avoidance of flatfoot and the making sure that the foot does not drop below a right angle will be of the greatest assistance in restoration of function in the knee joint.

ANKLE JOINT AND FOOT

LOSS OF FUNCTION in the ankle joint following trauma is most frequently the result of loss of the dorsiflexion foot function. An ankle

Arthroplasty.—Arthroplasty of the knee joint is indicated only in selected cases. In severe fractures into this joint, with bony ankylosis which has obliterated all signs of the joint surfaces and with the leg in fairly good position it is never indicated Stability of the knee joint is the first consideration and the risk of giving a flail joint in such cases must be borne in mind In cases of bad displacement, such as a marked flexion of the lower leg with a stiff knee joint, especially in younger individuals the operation may be performed Unless one can be quite sure of remodeling a good firm knee joint it is better to straighten the leg and allow it to ankylose again in this improved position In many cases of infection where bony ankylosis has occurred without complete loss of the contour of the joint surfaces arthroplasty is indicated but only after several months have elapsed since the active infection has ceased

In 1919 I observed Dr Putti of Bologna, Italy perform this operation and was impressed with the extreme care with which he remodeled the exact contour of the condyles and the normal depressions in the head of the tibia followed by a most painstaking relining of the joint by a pedicle fascial transplant He demonstrated 13 cases operated on in the past all of which had more than 75 per cent function in the knee joint.

Active and Assisted Active Movement.—Success in these cases since then has been due to the proper selection of the subject the care exercised in remodeling the articular surfaces the use of a sufficiently large fascial transplant, long-continued traction and the early use of assisted active motion to at least 50 per cent of the normal joint movement, followed by active motion in the knee joint after six weeks and associated with physical therapy until the greatest possible function is obtained.

Encouragement of these patients to persist in their efforts to regain function is of the greatest importance One should make some form of measuring appliance showing the limitation of motion before the operation and the increase in the amount of motion gained as time goes on. Nothing is so encouraging as actually visualizing the progress in the range of joint movements

This measurement of joint movement during the period of treatment of any of these old joint injuries is always an incentive to encouragement and coöperation on the part of the patient.

Following certain very severe traumas of the knee joint with marked loss of substance but more often following attempts at arthroplasty, *the flail knee joint* develops.

Mechanical splints leather knee jackets and stationary or hinged splints have been developed for the protection and comfort of these flail knee joints. Operative procedure for the purpose of an arthrodesis is indicated in most of these cases Prolonged fixation with the leg in the extension position must follow

Early mobilization of the various joints involved in the ankle and foot is imperative if fibrosis and a certain amount of stiffness are to be avoided. The foot and ankle stand immobilization better than the wrist and hand due to the fact that these patients are usually up on crutches are swinging the foot and lifting it into different positions, and frequently bear a certain amount of weight upon the extremity even though it is in a cast. Immobilization with a certain amount of function continued is less disastrous than immobilization with com plete absence of function

The badly swollen foot which results from crushing trauma should be relieved as soon as possible. Hemorrhage under the strong fascia of the foot, if allowed to persist, often results in a fibrosis We do not see the effects of ischemic paralysis in the foot as often as in the upper extremity We see the congealed foot oftener than the congealed hand This usually follows a prolonged persistent swelling and especially a persistent swelling combined with prolonged immobilization. It always results in a painful foot and is usually accompanied with cyanosis clammy skin thickened hard swollen tissues and a stiff useless foot.

Treatment.—The acute conditions of the foot and ankle and vari ous deformities of these parts are treated in other chapters Treatment here will be limited to the restoration of function in old disabling con ditions following traumas to these joints

TRAUMATIC ARTHRITIS OF ANKLE JOINT

Traumatic arthritis of the ankle joint occurs in older individuals who usually show a tendency to arthritis in other joints A severe con tusion of the ankle joint in an old individual may result in this condition. The early x rays are frequently negative and the condition is treated as one of contusion and sprain At first there may be con siderable mobility in the ankle joint, but this gradually decreases and pain is complained of more and more. After a few weeks a second x-ray is taken which usually reveals osteo-arthritic deposits along the astragalus or tibial surfaces of the joint or an area between the tibia and external malleolus of the fibula. Prolonged immobilization especially in older individuals is to be avoided as far as possible When there is a possibility of joint cartilage injury in these contused sprained traumas traction with separation of the joint is essential Every day or every other day the extremity should be released from traction how ever and heat massage and active exercise by flexion extension and lateral movements should be allowed. Passive movements with the dan ger of carrying these exercises beyond the pain point is never indicated Too early weight bearing frequently predisposes to osteo-arthritis in this joint. However after the condition is established and sta tionary weight-bearing although painful should be encouraged Per

joint may completely lose its lateral movement and yet, if this power of dorsiflexion of the foot remains the patient can be comfortable and useful. Loss of anteroposterior movements of the ankle joint, especially in the equinus position, is the most disabling

Injuries which destroy the normal vertical weight bearing angle through the ankle joint always result in a certain amount of loss of function This may follow fractures in the lower end of the tibia and fibula Pott s fractures, with a backward angulation of the distal fragments, rarely a forward angulation of these fragments and a fracture through the lower end of the fibula, often resulting in an abduction deformity followed by a traumatic valgus position of the foot. A traumatic varus position frequently follows fractures through the malleoli All these result in a loss of the vertical weight-bearing angle.

INTRA ARTICULAR INJURIES

Intra-articular injuries may result in a traumatic arthritis, due to damage to the joint cartilage, a contusion of the joint followed by infection with or without the formation of pus, fractures extending into the joint with a fragment of the fracture protruding into the joint forming this type of arthritis or partial or complete dislocations of the ankle joint In the latter, a separation between the astragalus and the external malleolus often resulting in a valgus position and a partial forward slipping of the tibia on the astragalus is not uncommon.

PERIARTICULAR INJURIES

Periarticular injuries most often resulting in loss of function are severe crushing injuries of the ankle with fibrosis of the capsule, liga ments aponeuroses and tendons Infections following severe injuries in the neighborhood of the ankle, resulting in the same fibrosis, and tears of the lateral ligaments following severe sprains or sprain frac tures. The whole condition often results in a weak ankle or turning of the ankle.

The ankle joint and joints of the hind foot and the joints of the forefoot are so closely related in function and several of these are so frequently involved concomitantly in the injury that restoration of function usually involves consideration aimed both at the ankle and the foot.

Prevention of Loss of Function.—Every injury in the foot and ankle must be treated from the standpoint of maintaining the vertical weight bearing angle the maintenance of a dorsiflexion of the foot to at least a 90° angle and the preservation of the longitudinal arch of the foot.

A slight varus position of the foot is always to be preferred to a valgus position Every effort must be made to prevent either of these conditions from developing as a permanent deformity

least two weeks During this period the use of diathermy will help relieve the pain and swelling In the absence of diathermy hot fomentations or the contrast bath 12 min of a hot local foot bath then 3 min. of a cold local foot bath or alternating hot and cold fomentations will all help decrease the marked swelling and reaction about the ankle and foot. A pillow or blanket splint during this period will prevent redislocation and is usually all the splintage that is necessary From the third to the seventh day very slight assisted active exercises may be used. During this period massage of the foot, ankle and leg following the direction of the venous flow and given daily is indicated After a week the amount of active exercise can be increased At the end of two weeks a light, molded boot splint holding the foot always at a right angle and protecting the back and sides of the ankle can be applied and the patient allowed up on crutches He may now go home and report for physical therapy treatments at least every other day These consist of heat massage, and an increasing amount of exercise At the end of a month, weight-bearing can usually be allowed. The contrast bath used two or three times at home by the patient with frequent periods of rest with the leg elevated higher than the buttock will prevent the swelling of the foot so common in fractures and dislocations in this region. From the fourth to the sixth week it may be necessary to protect the ankle by a firm bandage or adhesive strapping but at the end of that period if the above active treatment has been carried out recovery is usually complete

OLD DISLOCATIONS OF ANKLE JOINT

Old complete dislocations of the ankle are seldom seen. Operative procedure is usually necessary to overcome the contracted tendons fibrosis, and the malposition of the bones when one of these cases of old dislocation is seen I have had only one such case.

Old partial dislocations with loss of function are not uncommon. Closed manipulation with a Thomas wrench will usually overcome lateral or medial partial dislocations This should be followed by from two to six weeks immobilization in a foot splint The latter should be removed daily or every other day after the third day for hot contrast baths massage, and assisted active and active exercises Occasionally I put on a cast with walking calipers and do not remove it for three weeks Every effort must be made to prevent fibrosis within the ankle joint or foot joint by maintaining mobility and exercise to as great an extent as possible.

Anteroposterior partial dislocations of long standing may be reduced by closed manipulation under anesthesia. If this fails, however operative interference is necessary Occasionally a tenotomy on the tendon Achilles, combined with closed manipulation will overcome the deformity Here again the same sequence of physical therapy to restore function is indicated

sistent use of heat massage, and exercises combined with weight bearing will often gradually smooth the small osteo-arthritic deposits so that walking can be performed without pain

PURULENT ARTHRITIS OF ANKLE

Purulent arthritis or direct infections of the joint from compound fractures into the joint compound dislocations or direct injuries always require adequate drainage if pus forms Drainage tubes into the joints are not indicated They may be placed down to the joint. Bilateral incisions with drainage down to the joint may be necessary but

FIG 32—Case of purulent arthritis of ankle joint.

a through-and through drainage tube practically always means erosion of the joint cartilage Frequent active movements of the joint are indicated during this period of drainage (Fig. 32)

DISLOCATIONS OF ANKLE JOINT

Dislocations of the ankle joint are to be reduced at once Prolonged immobilization in a cast following reduction is never indicated even though the application of a cast to the dislocated foot will allow the patient to be up and around on crutches After reduction of the recently dislocated ankle the patient should be treated in bed for at

are seldom markedly displaced. Rest in bed and traction to keep the joint surfaces separated combined with heat massage and early active motion will usually give a good functional result

DISLOCATIONS OF ASTRAGALUS

Dislocations of the astragalus are not uncommon Cotton describes eleven different varieties of this injury It is frequently accompanied with open lesions Marked damage to tendons and to the ligaments of at least four of the foot joints usually accompanies this dislocation.

Effort should be made to reduce these dislocations by the closed method as soon as they are seen Reduction may be aided by the Thomas wrench. Failure at closed methods should be followed by an attempt at open reduction Pressure of the dislocated bone upon the soft tissues soon results in sloughing and infection The latter is a serious complication in this condition Therefore great effort must be made not to damage unduly the tissues during the attempt at closed reduction and failure of this method should be followed at once by an open arthrotomy If the injury is a pure dislocation and no fracture is present it can usually be reduced Complete removal of the dislocated astragalus is sometimes necessary but it should be avoided when possible If it is complicated with fracture it is almost impossible to reduce the dislocated fractured fragments and its removal is therefore necessary Never should pressure necrosis and the dangers which follow this be allowed to develop from leaving a dislocated fragment of the astragalus intact.

Following reduction redislocation is very rare and need not be greatly feared during the active treatment of the condition Mobilization of the foot with heat and active movements are far to be preferred to immobilization by cast treatment. Great attention must be paid to the protection of the badly contused often partially necrosed soft tissues Figure 33 illustrates one of my cases in which the dislocated astragalus was replaced this treatment being followed by early use of heat massage and active exercises The result was the complete restoration of function within six weeks

FRACTURES OF THE TARSAL BONES

Fractures of the os calcis astragalus scaphoid cuboid and any of the cuneiform bones seldom occur without a certain amount of damage in the adjacent joints of the foot. Much of the pain and disability which follow fractures of the os calcis are due to associated joint injury in the astragalus-calcaneus joint either the result of the trauma or the result of the prolonged treatment of this fracture

Fractures in the bones of the foot necessarily require a certain amount of fixation Every effort should be made for the best possible re-apposition of these fractured fragments otherwise painful foot may

FRACTURE OF MALLEOLUS

Fracture of either malleolus with marked separation between the malleolus and astragalus may result in a gradual valgus or varus position when weight bearing is allowed Reposition of these malleoli to a position as nearly normal as possible is therefore indicated in all such fractures. As a rule, in the marked displacement of the malleolus following fracture especially the internal malleolus, I make a small semilunar incision over the anteromedial aspect of the ankle joint, avoiding the tendons and exposing the fractured fragment The displaced malleolus is pushed or hooked up into its normal position the fractured surfaces being carefully approximated Two mattress sutures of No. 2 chromic catgut are then applied through the fascia and periosteum of the fractured fragments and tied, thus holding them in close apposition A second line of continuous catgut is sewed through the torn fascia to strengthen this fixation and the wound is closed without drainage

In addition to the advantage of replacing this fractured fragment a large amount of old blood and blood clots is evacuated from within the ankle joint. I have performed this operation some eight or ten times, and in every case there is always a marked hemo-arthrosis. These patients recover more rapidly and with better functional results than do those whom I have attempted to treat by the closed method. It is indicated only when there is marked displacement of the malleolus. When these cases are treated by the closed method aspiration of the hemo-arthrosis is indicated, if as often happens, there is marked swelling of the ankle joint.

A boot or stirrup splint with the ankle slightly inverted is applied following either the closed or open method of treating these fractures. If the external malleolus is involved a straight position of the foot is preferable to inversion. Extreme inversion as formerly practiced is seldom necessary From three to seven days following the application of the splint it is removed and massage of the foot, ankle, and lower leg is given This is repeated daily or every other day until the tenth to the fourteenth day By this time the wound is healed The stitches are removed and heat massage, and slight active movement can be started By the end of the fourth week considerable active movement on the part of the patient may be allowed without danger of refracture Here again, contrast baths, various forms of heat applied daily or every other day massage, and frequent periods of active movement will hasten recovery and will prevent the prolonged swelling in the ankle and foot which practically always follows six weeks of immobilization in a cast

FRACTURES INTO ANKLE JOINT

Fractures through the infra articular face of the tibia and fractures through the articular surface of the astragalus are not uncommon but

These cases should be treated either by prolonged gradual mobilization of the joint by physical therapy methods or by a period of physical therapy followed by manipulation.

Heat and Massage —Heat is always indicated It may be given as diathermy hot fomentations hot baths and preferably contrast baths or hot paraffin baths as advocated for the hand Massage first of the stroking and later of the kneading type accompanied with a sense of stretching and freeing of adhesive bands should be given daily

Exercise.—Exercise especially active movements by the patient himself is most valuable If there is no contraindication for active use of the foot, mechanical apparatus may be used to increase the amount of exercise Pedaling a sewing machine or a jig saw is a good

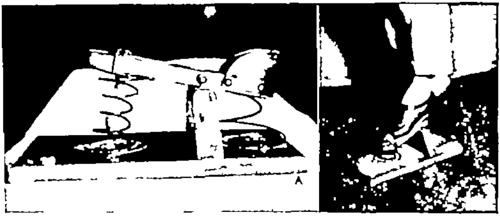

Fig 34.—A an ankle exerciser B same as Fig. 34, a

occupational therapy maneuver Figure 34 shows an ankle exerciser which has been very beneficial in overcoming stiff ankles due to fibrous ankylosis Pedaling a bicycle is another excellent exercise. The bicycle can be made stationary by holding the rear wheel from the floor on a bracket. None of these exercises should be persisted in until the part is fatigued and if swelling or reaction follows the amount of exercise must be decreased

Forceful Manipulation —Forceful manipulation of the stiff ankle joint under anesthesia is a questionable procedure although the ankle joint will stand this better than most joints Some advocate forceful correction securing a certain amount of joint movement and then placing the ankle joint and the foot in a cast to hold this movement for a few weeks and then repeating the maneuver Personally I am opposed to the cast immobilization, especially immediately after

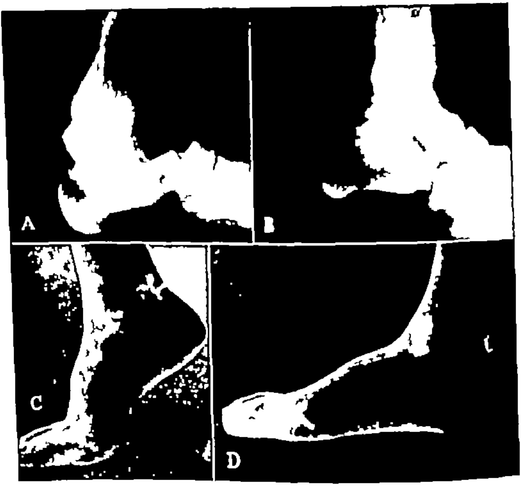

Fig 33.—*A* author's case of complete dislocation of the astragalus, *B* same as Fig. 33 a, following operative replacement of the dislocated astragalus; *C* illustrating the amount of function in the same case six weeks following the injury *D* same as Fig. 33, c.

follow Seldom should immobilization of these fractures be permitted for more than two weeks without removal of the cast or fixation splint for the purpose of heat contrast baths massage and ankle movement. The day of prolonged immobilization of the foot in a plaster cast followed by weeks devoted to overcoming the swollen edematous condition of the member and the pain and stiffness so common in foot injuries has passed. There will always be a certain number of these complications but closer attention paid to physical therapy measures herein outlined will prevent the majority of them.

STIFF ANKLE JOINT DUE TO FIBROUS ANKYLOSIS

This is usually due to prolonged fixation following fractures in the lower extremity or to sepsis following either local trauma or a secondary infection As a rule, the ankylosis is in a faulty position and too often it is accompanied by a certain amount of footdrop

BONY ANKYLOSIS OF THE ANKLE JOINT

If the weight-bearing angle and the position of the foot are practically normal it is questionable whether an attempt should be made to overcome the stiffness When the ankle joint, however is ankylosed in a faulty position operative procedure is necessary Sometimes only a wedge of bone from the anterior portion of the ankle joint is removed to allow the foot to be brought to 90 of dorsiflexion. Sometimes the operation is for the removal of an obstructing piece of bone which has been displaced into the joint at the time of the fracture Sometimes a refracture through the lower end of the tibia and fibula with a resetting operation to restore the weight-bearing angle is all that is necessary In a few cases a typical arthroplasty of the ankle joint may be indicated

Whatever the operative procedure it should be followed routinely by heat, massage and exercise in order to restore the greatest possible amount of function

A cautionary note must be added concerning too early operations on the ankle joint, following a septic process An infection at the site of a partial or complete arthroplasty can very easily spoil the result. Likewise too early weight bearing following an arthroplasty can start up an osteo-arthritis in this joint which will be disabling Here again a prolonged period of traction is indicated following the operation. In many of these cases a walking caliper with traction from a shoe to the end of the caliper can be used This will keep the joint surfaces separated and at the same time will give the healing advantages and function restoring proclivities of the use of the leg and foot

THE "CONGEALED FOOT"

Mention has already been made of the congealed foot The entire foot is swollen and firm The skin is stretched blanched or cyanotic, is usually cold and is often covered with a clammy sweat The swelling usually includes the entire front portion of the foot from the astragalus to the toes The patient complains of pain and because of the pain he seldom bears any weight upon the extremity He either uses crutches or hops When visited in his home he will be found going around the house resting the knee of the injured extremity upon a straight-back chair and moving this chair with him I have recently seen a case of this nature of four years standing Several years ago I had such a case referred to me from Jefferson Barracks which had persisted for two years A heavy object fell upon this patient s foot fracturing two of the metatarsals The foot was badly swollen from the time of the accident and this swelling which was at first somewhat edematous and soft gradually became firm but persisted the entire two years I treated this foot for eight months without relieving the

manipulation under gas, because of the danger of swelling and traumatic reaction from the treatment

After two weeks of a very active physical therapy *régime* as outlined just above, more forceful manipulation of the ankle may be considered These two weeks of prolonged physical therapy often show whether there is a tendency for recurrence of an old infection. A slight inflammatory reaction or even a cellulitis may develop around old scars. Certainly no manipulative procedure should be carried out in the presence of a potential infection If there is no reaction after two weeks of strong massage and active exercise and especially if the parts have been loosened up somewhat by this procedure forceful manipulations, preferably without anesthesia, may be considered The foot is grasped and strong traction is made downward from the ankle joint Usually there is a certain amount of footdrop present Gentle but increasingly strong flexion and extension of the ankle joint, working it back and forth, followed by strong lateral movements are now carried out by the surgeon. The patient will usually complain of pain but as a rule it is not severe A sensation of stretching and sometimes of a sudden tear of an adhesion followed by a more marked movement of the foot frequently accompanies these maneuvers. Immediately following manipulation heat the whirlpool bath or a local foot bath is used and the patient is instructed to keep moving his ankle to maintain the amount of movement gained The heat massage, and exercise are persisted in daily and after a week a second forceful manipulation is carried out Thus by alternating physical therapy and manipulation, function can be restored in the majority of cases of this nature

Occasionally a tenotomy on the tendon Achilles is necessary Sometimes a great deal of time and effort must be expended to overcome swelling in the foot the poor circulatory condition of the foot, and the footdrop before the ankle condition can be manipulated Occasionally the above manipulations must be carried out under anesthesia. When this is done the Thomas wrench is usually used The condition to be corrected is usually an equinus position of the foot with an extensive area of fibrous adhesions between the end of the tibia and the bones of the foot or between the fibula and the bones of the foot Correction of this deformity by forceful manipulation with the Thomas wrench may require a certain amount of fixation of the foot in the corrected position to prevent recurrence A metal aluminum splint or a plaster splint moulded to the back and opposite side of the foot leaving the injured areas open for the application of heat and massage, is better than the application of a plaster cast. Within three days the immobilization splint can be removed for a treatment of heat massage, and slight exercise, after which the splint is reapplied The more frequent the periods of mobilization and exercise following forceful manipulation the less danger there is of recurrence of the condition

This treatment is persisted in for from two to three weeks Occasionally the patient will bear weight upon his foot gingerly at the end of that time but as a rule, weight-bearing will not be tolerated. However, improvement in the condition depends to a large extent upon redeveloping function. Two years ago Dr Ralph Carothers of Cincinnati Ohio suggested to me the use of a walking caliper in these old congealed feet Since then I have used it in two cases with what I consider excellent results

USE OF WALKING CALIPER.—A plaster cast is applied from the toes to just below the tibial tuberosity at the knee In this cast is encased a walking caliper The patient is then given a pair of crutches and taught to walk, bearing the weight of the injured leg upon the iron loop of the caliper projecting below the cast. After the patient has learned to walk with this caliper he is allowed to go home and persist in this walking for four weeks He then returns to the hospital or the physical therapy laboratory when the caliper is removed and another séance of two to four weeks of heat massage and efforts at active exercise are carried on. Again the walking caliper is applied and the patient is allowed to return home for another period of four weeks Usually upon his return at the end of this period and following a period of massage and exercise the patient can be persuaded to walk in a shoe the leather of which has been cut so that it will fit his foot If possible he is persuaded to give up crutches and use canes Continued use of the foot with continued contrast baths massage and exercise usually completes the cure of this condition. The treatment often must be persisted in for months.

CASE IV—Figure 35 shows a foot which was so badly crushed that amputation of three of the toes was necessary The foot remained badly swollen and developed into the typical congealed foot The patient was referred to me from West Virginia His local physician according to the patient had advised an amputation above the ankle He had been treated by every kind of light known" so he stated He was finally pronounced a permanent total disability case When he was referred to me four years had elapsed from the time of his injury At the first examination the patient would not allow me to touch the stumps of the amputated toes. He wore padding inside his sock over the amputated stumps and wore no shoe He was using crutches but walked around the office by hopping The foot was swollen more than twice the size of the well foot. My first inclination was to advise an amputation of the leg at the site of election, viz., the junction of the lower and middle thirds of the tibia. Before recommending this however I placed the patient in the hospital and started the above treatment At the end of two weeks I was able to massage lightly over the end of his stump and could massage the rest of the foot The walking caliper was applied and he was allowed to return to his home He used the walking caliper for six weeks before he reported again The extra two weeks were added by the patient because he dreaded to give up the caliper He remained in the hospital two and a half weeks for physical therapy as

condition Five years later I heard that this patient was still using crutches.

The prevention of this condition is to relieve the persistent swelling which frequently follows crushing injuries of the foot. The presence of a fracture should not explain the swelling and lull the surgeon to sleep over the condition It is practically always due to hemorrhage over the dorsum of the foot and under the thick plantar fascia. If, within a short time such a foot does not yield to the elevated position with the application of hot and cold fomentations and the use of the contrast bath it is wiser to make several small incisions and evacuate the blood clot and the blood serum than to leave these in place to become organized shut off the circulation, probably develop a low-grade cellulitis in the foot with a certain amount of endarteritis and finally, the "congealed foot."

When such a case presents itself, the surgeon is immediately confronted with two problems (1) how to overcome the pain in this foot so that the patient will tolerate a certain amount of massage and assisted active motion as a rule, such a patient is very nervous, he is afraid to let the surgeon touch his foot even for examination and will jerk it away at the least attempt at massage and (2) how to secure the great advantage of function and exercise to help overcome the condition—in other words how to make the patient walk on this extremity The habit of not using it for months and often years must be overcome.

Improvement of Circulation.—Such a patient should at first be treated in the hospital The first efforts are directed toward improvement of the circulation As described in similar conditions in the hand, the contrast bath is an excellent stimulation of circulation. The foot is immersed in a local foot bath with the temperature of the water from 100 to 110° F (37 7 to 43 3° C) or more if the patient can stand it. After 12 min. of this bath, the foot is immediately immersed in a second bath of cold water of approximately 40° F (4.4 C) for 3 min This contrast bath is repeated three times and given twice daily The patient is then put to bed and the foot is elevated on pillows and encased in large, hot fomentations, the base of the fomentations being a saturated solution of magnesium sulphate. The fomentations are changed every two hours. For a period of one hour between each change of the fomentations the foot is placed under an infra red lamp or an electric baker In the evening the contrast bath is repeated and the fomentations and light are kept up during the night. After three days of this treatment, light massage is started in the nature of stroking beginning at the toes and extending up the foot and leg in the line of venous flow The strength of this massage is increased as the patient can stand it. If the skin shows signs of becoming water logged, the hot fomentations and contrast bath are replaced by the hot paraffin bath as described under Hand Injuries.

Functional Joint Conditions

This could make a chapter in itself and therefore only a few of the conditions will be mentioned

TRAUMATIC NEUROSIS

The more cases of trauma one sees the less is his tendency to diagnose them as traumatic neuroses Many of the latter have as an underlying basis a minute, often undiscoverable organic lesion which if ferreted out accounts for the apparent neurosis. A small adhesion within the knee joint may cause pain upon certain movements Physical findings are practically negative and the x ray is of no assistance. The patient however learns to avoid these sensations of pain by developing the habit of avoiding the given movement A faulty function of the joint follows The patient may visit many physicians who failing to find an organic explanation of the condition tell him there is nothing wrong and that it is only a nervous condition The oftener he is told this the more self-conscious he becomes and the more he feels misunderstood Naturally such a patient develops a certain amount of neurosis Therefore before classifying any patient as neurotic, careful search should be made for all possible organic explanations of the condition.

Many cases of joint injuries are treated by prolonged immobilization with disuse of the muscles and nothing special is done to preserve muscle coördination and joint sense As far as ordinary examination goes and as far as x ray evidence shows the trauma of the joint is "cured However the patient cannot or will not use the member At examination the surgeon too often gives his sole attention to the patient s exaggerated efforts to use the member and to the neurologic findings of atypical areas of anesthesia and changes in the temperature sense. Most of us fail to grasp the fact that prolonged immobilization and disuse lower the sensitiveness of the sensory nerve endings and therefore may contribute to the neurologic signs frequently responsible for the diagnosis of neurosis Finally seeds of phobia are often planted in a patient s mind by the physician the relatives or by some interested lawyer and these fears combined with the long disuse of the muscles and joints may be the underlying cause of his neurosis I am quite sure that in the above-described case of congealed foot," the removal of fear of amputation and of permanent disability and the encouragement given to this patient during the period of his treatment decreased considerably the symptoms of neurosis which were discovered in his case during his first two weeks in the hospital. For example this patient had atypical areas of anesthesia over his foot and lower extremity These areas of anesthesia were variable that is they were present in one area at one examination and at the second examination were absent over that area but present over another He

above outlined During this period he went to the occupational therapy department and pedaled the jig saw Instead of replacing the walking caliper he consented to use an old shoe which was cut to make it very loose With the aid of crutches he walked with the shoe bearing very little weight upon the foot He was allowed to return home for another month and is now back in Chicago receiving further physical therapy He has a new pair of shoes of the blucher type The top of the shoe at the base of the tongue was cut and a piece of leather approximately two inches wide was sutured in to make the shoe large enough to accommodate his foot. He is

FIG. 55—Walking caliper in case of congealed foot.

walking with the aid of two canes After two weeks of further physical therapy he reported to my office with practically no swelling in the foot. He had had a shoemaker remove the piece of leather inserted in the top of the new shoe thus restoring the shoe to normal showing that the swelling had disappeared. That day he had walked six miles, using his canes only for assistance He informed me that he intended to walk back to his hotel after leaving my office—a distance of a mile and a quarter This patient is almost cured, but treatment will continue until he has discarded his canes I believe he will be able to return to light work in another two months.

immediately the wrist flew into its stiff position and the fingers became extended and rigid I immediately ordered the patient up for a second anesthetic but he refused to go I then told him that I would try to reduce the condition under local anesthesia A rather large, dull needle was used and salt solution was injected on the dorsum of the wrist and hand This was done none too gently and the patient complained bitterly I told him that the injection must be made several times until we began to notice movement in his wrist and fingers. Injections were repeated and attempts made to move these parts. Finally a little motion was gained and was gradually increased until again we had the wrist dorsiflexed and the fingers completely flexed. They were again bandaged in this position Three days later the bandages were removed and although some stiffness returned, we were able to secure considerable movement in the wrist and fingers. Again they were bandaged in the flexed positions. Two days later the bandages were left off and massage and joint reëducation exercises were started The patient was told to make pulp balls and each day he was to give me from 12 to 20 pulp balls on my return visit. Within two weeks the condition was cured. In my judgment this was a true case of traumatic hysteria.

CASE VI —A second patient was recently referred to me with a stiff knee joint. He had been operated on some eight months previously for a dislocated internal semilunar cartilage. Following this operation a plaster splint was applied to the posterior aspect of his leg and thigh and was left in place for six weeks before it was removed. Many attempts had been made to secure movement in the knee but without result. The patient walked stiff legged with a rather exaggerated limp and complained of pain in the knee I kept this patient at the hospital and started physical therapy in the form of heat, massage, electric stimulation of the muscles, and assisted active exercises. Within two weeks the patient had developed a 45 flexion of his knee Progress seemed stationary at this point. Under general anesthesia I was able to secure 90 of flexion of the knee joint without any trouble. The knee was bound in this position and the patient allowed to awake. He complained of some pain and discomfort but seemed happy over the amount of flexion obtained While he was under the anesthetic further flexion seemed limited. This limitation of motion gave the sense of fibrous limitation rather than of bony obstruction. Undoubtedly a certain amount of contraction of the capsule and ligaments and foreshortening of the weaker flexor group of muscles accounted for this limitation of flexion Further physical therapy was given and we were always able to secure the 90 flexion of the knee. Further flexion was gradually returning It was my opinion that this patient would make better progress at work rather than by continuing physical therapy treatments therefore he was discharged

Two things had happened to account for this patient's neurosis Right after the operation the doctor had told him that he had cut one of the ligaments and that the sewing up of this ligament had shortened it so that the patient must not expect to have full range of motion in the knee joint. The surgeon who performed the operation lived in another town When he saw the patient at the end of six weeks with the posterior splint still in place, he criticized the local doctor in the presence of the patient, stating that the splint left on so long was liable to make a stiff knee In my opinion these two things contributed to the neurosis. After returning home this patient refused to go to work until a settlement was made for his knee

made exaggerated efforts to swing his lower leg when first examined and, as one of my assistants expressed it, "If his foot wasn t so swol len, I would call him a neuro " All these signs and symptoms have disappeared with the improvement of the condition of the foot

A pure traumatic neurosis in a joint usually gives the picture of a stiff joint Occasionally it is a flaccid condition of the joint The history of injury is often very slight When the condition of marked stiffness develops immediately after a slight injury I am more suspicious of its being a neurosis than when it develops several days or weeks after the injury In the latter I am suspicious of adhesions or of other causes of painful joint which hold it rigid Frequently the hysterical stiff joint has only the manifestation of stiffness and there is no complaint of pain If the condition is seen early there is no swelling. If areas of anesthesia are found about the joint early, I am more suspicious of their being due to a functional condition than when they are seen late and after long disuse of the muscles In the latter instance the condition may be due to lowered sensitiveness in the sensory endings

Examination under anesthesia is one of the best means of differentiating between the functional stiff joint and the stiff joint due to some obscure internal derangement.

CASE V—This patient was referred to me for a stiff wrist joint The condition followed immediately after a falling rock hit the back of the patient's wrist during a blasting in a quarry His physician stated that the wrist was never swollen but that the patient complained from the start of severe pain The wrist was held perfectly straight and rigid with the fingers rigidly extended The patient would not tolerate manipulation because of alleged pain. He was seen by me some three months following the injury By this time the rigid position of the wrist and hand had caused a certain amount of slight swelling and cyanosis in the extremity (Try holding your own hand rigid in an awkward position for 30 min and note this tendency to swelling and cyanosis) Physical examinations were negative except for the rigidity and alleged pain over the back of the wrist and hand. The entire dorsum of the hand showed anesthesia to pin prick X ray examination was negative. The condition persisted even when the patient was asleep It was explained to the patient that a diagnosis could not be made without an anesthetic.

Under rather deep anesthesia I was able to flex and extend the wrist without any evidence of resistance as from adhesions or bony obstruction. The fingers could likewise be flexed and extended. The wrist was placed in dorsiflexion, the fingers completely flexed, and the thumb abducted, and then the entire hand and wrist were firmly bandaged in this position. The patient was allowed to awake from his anesthesia and was returned to bed. When he became sufficiently awake to realize the position of his hand and wrist, he cried bitterly and complained of pain Sympathy without censure was given to him. Sedatives were administered, and after he awoke from them his complaints of pain were less violent The next day the bandages were removed for the purpose of exercising the wrist and fingers. Almost

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disability thus the possibility of a compensation neurosis was injected into the case.

COMPENSATION NEUROSIS

Often this desire for settlement, in public or industrial accidents, furnishes the basis for the neurosis The term ' compensation neurosis" best explains this condition However, surgeons must be careful not to make this diagnosis until they have ruled out all possible organic lesions and all pure neuroses which may be the true cause. The tendency to pin 'compensation neurosis' upon these injury cases is becoming more prevalent than the often made diagnosis of malingering.

MALINGERING

True malingering is a rare condition Most cases must be placed under careful observation in the hospital before this diagnosis can be definitely proved When the nurses internes, or orderlies discover that a patient with an alleged stiff joint is using that joint in the bathroom or while playing a game of cards with the other patients in the ward and that it again becomes stiff as soon as the surgeon comes to the ward one can definitely diagnose malingering

Many cases physically and mentally weakened by prolonged suffering develop neuroses. Gradually they come to realize that they can use the given joint, but the habit of loafing and of depending upon others and the dread of again assuming the burdens of life cause them consciously to hold fast to their complaints and add other signs and symptoms to the condition. Often the question of settlement is involved These are the cases of traumatic hysteromalingering that are far more common than pure malingering.

In functional conditions of the joint one must avoid getting into a rut of treatment. I have had physicians say to me Here is a case of traumatic hysteria. I have told him there is nothing wrong with him, but we keep him satisfied by giving him a light treatment two or three times a week. What a poor treatment for neurosis! On the one hand his physician tells him there is nothing wrong with him, while on the other hand he has him reporting for treatment. No wonder his neurosis is at a standstill or grows worse

The use of physical therapy as a means of 'suggestive treatment" or for its 'psychologic effect is a very questionable form of therapy It is easy to stimulate ideas of grandeur and enhance the seriousness of the case in the patient's mind with physical therapy when a functional condition is the underlying cause of his disability You can sometimes rub in more neurosis in an hour than you can rub out in a year

FORMS OF PHYSICAL THERAPY

This chapter has been written for the average surgeon who must depend upon the intelligent use of his hands and the common-sense use of the ordinary physical therapy apparatus usually available for the treatment of his cases.

Machines.—Diathermy machines expensive quartz lights various kinds of electrical apparatus and other more or less complicated forms of machine therapy should be provided by a physician in your community who is specializing in physical therapy Every hospital should have a thoroughly equipped physical therapy department supervised by a physician familiar with the use of these more expensive and more complicated types of physical apparatus. The surgeon should be able to refer his cases to such a department for intelligent, common-sense physical therapy treatment. On the other hand the surgeon should not lose interest in his case when it is referred for such treatment. It is only by close coöperation and coördination of effort between the physical therapy department and the surgeon that the best results in functional restoration can be secured

Occupational Therapy —Occupational therapy should be made a definite part of or should be coordinated with, the physical therapy department. There is an increasing number of well trained physical and occupational therapy technicians who can be placed in these departments To leave the physical therapy and occupational therapy to the technicians, unsupervised by a physician especially qualified in physical therapy or if this is impossible unsupervised by the surgeons in the hospital interested in securing functional restoration is a mistake The departments will grow and increase in usefulness just as the interest of the staff in these departments grows The technicians realize this fact and are most anxious to have their work supervised.

Importance of Physical Therapy —When physicians and surgeons realize that physical therapy definitely belongs to the medical and surgical field they will cease sending these cases for unsupervised treatment to laymen who are developing so-called physical therapy offices in almost every city Masseuses gymnasts health institutes osteopaths, and others who are treating all comers by their various methods of massage manipulation and exercise instead of working in close coöperation with the physicians who know the needs of their patients belong in the class of cultists.

In this chapter on joint injuries I have gone into considerable detail concerning the physical therapy measures employed for each individual joint The surgeon must realize that the problem is more complicated in many of these cases than the mere heating massaging and exercising of the given joint. The joint is a component part of the extremity The injury itself or the prolonged disuse of muscles,

nerves, tendons, and ligaments in the remaining portion of the extremity may account for the loss of function No matter how much attention is given to restoration of function in one joint, our efforts may be nullified if we fail to treat the joints, muscles, nerves, and other soft tissues in the rest of the extremity

Coördination of the muscles and redevelopment of joint sense are essential in restoring joint function Thus, in injuries of the lower extremity, the entire attention must not be directed to the stiffened knee The patient must be taught how to swing his entire leg, how to abduct and adduct the leg how to flex and extend his foot, how to walk in a straight line climb stairs, and climb over objects, how to stand on his tiptoes and similar exercises, all directed to reëstablishing muscle coördination

Influences such as gravity and other conditions responsible for the assuming of faulty positions in an extremity must be constantly guarded against by the use of proper splints, traction and corrective exercises Often the strong group of muscles so dominate the function in the leg that the weaker antagonists cannot act This is seen in injuries of the shoulder joint when the strong pectoralis major and the latissimus dorsi muscles have become overcontracted during a period of arm adduction fixation Here gravity plays a part in further weakening the abductors. Therefore, during the treatment of the upper extremity injuries attention must be given to maintaining function in the weaker muscles to developing coördination between the abductors and adductors and to protecting the part against gravity The wristdrop and the footdrop are other excellent examples of the deforming effect of gravity

Coöperation of Patient.—Finally *the patient cures himself* In all cases of old joint dysfunction and deformity the ultimate restoration of function depends *chiefly* upon the patient. The surgeon builds the proper foundation for restoration and then becomes the guide and teacher but the patient *must* put forth the effort and stick-to-it iveness that results in the cure Both the surgeon and the technician must constantly impress this fact upon the patient. Unless you can secure his coöperation and unless he puts forth great efforts to show a slight daily or weekly improvement in his condition physical therapy will be of no avail.

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CHAPTER FOUR

PHYSICAL THERAPY IN BONE AND JOINT TUBERCULOSIS

WILLIS C CAMPBELL M.D

The occurrence of tuberculosis in bones and joints is but an incident in the dissemination of a constitutional disease orthopedic treatment alone is consequently ineffectual and every effort must be employed to eradicate the systemic infection The aim of antituberculosis therapy is to utilize to the highest degree the body s reparative powers by means of rest, a high caloric diet drugs tuberculin fresh air and sunlight. Orthopedic treatment, whether nonoperative or surgical, consists of measures which prevent deformity and immobilize the affected articulation until the tuberculous process has been arrested by natural forces The local and constitutional treatment cannot be dissociated except for convenience in description but since light therapy has such a definite action on the tuberculous process it should be employed routinely in every case of bone and joint tuberculosis

Etiology —The infectious nature of tuberculosis had been suspected for many centuries but it was not until 1882 that Koch succeeded in isolating and cultivating the tubercle bacillus Several types of tubercle bacilli are recognized but only two types the human and the bovine commonly cause infection in the human body The bovine type of infection is more prevalent in children than in adults the incidence of the bovine type constituting nearly one-third of the total number of cases in very young infants When all ages are considered the incidence of bovine tuberculosis amounts to only one-fourth of the total number of cases There is no essential difference in the pathologic reaction produced by the two organisms so that for practical purposes differentiation of them may be disregarded. The portal of entry in either case is through the mucous membranes of the alimentary canal or respiratory system. The invasion of these tissues is followed by tuberculosis of the lymphatic nodes cervical or mesenteric, and from this focus the bacilli are distributed through the blood stream to the bones or joints

In addition to the infecting organism two other causative factors should be considered first, the predisposition of the patient, and secondly the local conditions that favor the implantation and growth of the bacillus. Hereditary transmission has been disproved but direct infection from association with a tuberculous member of the family

is of frequent occurrence Mild trauma is an accepted predisposing cause, while severe trauma, as extensive fractures or crushing of the joint surfaces, is rarely, if ever, followed by tuberculosis Bone and joint tuberculosis is essentially a disease of childhood beginning more often between the ages of three and five but it is undoubtedly more common in adults than is generally known, as many cases of chronic arthritis continue until death ensues from other causes without a cor rect diagnosis having been made Joint tuberculosis is usually a mon articular affection The spinal column is affected most often, next in frequency being respectively the hip knee, and ankle joints, the joints of the upper extremity are less often invaded

Pathology —The tubercle bacillus causes inflammatory changes which are so characteristic that a diagnosis may be made by histologic examination even without the finding of the bacillus The histopathology of tuberculosis in a joint is the same as that of a tuberculous process elsewhere in the body Following the deposition of the tubercle bacilli in the tissues there is a proliferation of the cells lying in direct contact with the bacteria which results in the formation of a tubercle The microscopic examination in the early stage shows an accumulation of endothelial leukocytes and surrounding this, an area of lymphocytes. Later, the endothelial leukocytes in the center of the tubercle coalesce and form a giant cell of the foreign body type. At this stage, the giant cell is surrounded by a zone of amorphous glandular material. Encircling this and encroaching upon it, is another zone composed of endothelial leukocytes many of which show a radial arrangement of their nuclei. Finally there is an invasion by lymphocytes, polymor phonuclear leukocytes, and fibroblasts. As the lesion becomes older the fibroblasts are found nearer the center of the tubercle The blood vessels become occluded resulting in necrosis, and the toxins which are elaborated by the bacilli may also produce disintegration and caseation.

The pathologic process usually begins in the bone just external to the epiphysis in the vascular area known as the metaphysis, although primary tuberculosis of the synovial membrane is occasionally observed. There is a gradual atrophic and destructive process which invades the joint from without, the articular surfaces being undermined Coincidently with invasion of the bone, there is a sympathetic arthritis and after the joint is invaded there is a gradual proliferation of the synovia, hypertrophy of the villi, formation of granulation tissue in profusion and erosion of the articular surfaces There may be a change in relation of the joint, with malposition subluxation or complete dislocation. Cold abscesses are formed from caseation and necrosis, they follow the line of least resistance and appear beneath the skin as fluc tuating masses The evolution of the process requires from one to three years depending upon the joint involved the resistance of the individual and the virulence of the infection.

Symptomatology —The chief symptoms of joint tuberculosis are pain disability limp, swelling stiffness and night cries The physical findings are swelling of the joint, with or without apparent increase of the synovial fluid muscular atrophy on either side of the joint in creased local temperature and daily elevation of the general body tem perature. The onset is gradual and insidious spontaneous pain and pain on attempted motion are early symptoms The pain is referred to a more distant point in the extremity when the disease is in the proxi mal joints as the hip and shoulder when the disease is in the peripheral joints the pain is local Swelling is more apparent in the superficial joints and the local heat is usually increased. Muscular atrophy occurs earlier and progresses more rapidly than in other joint affections Mus cular spasm or rigidity is a characteristic manifestation Local symptoms are more definite in children than in adults

The muscular spasm limiting joint motion is less pronounced in adults and years may elapse before there is any material impairment of function This is due to the fact that the bones of adults are harder more dense and not so easily invaded as the bones of children. In the acute stage, deformity may be caused by muscular spasm but in the later stages the malposition may be attributed to muscular and ligamentous shortening to bony destruction or to ankylosis in a faulty position

At the onset the patient is usually well nourished and there may be no debility until the symptoms become acute with excessive pain and loss of sleep Loss of weight is rarely observed until the late stage or as the result of some complication such as secondary infection The temperature at the onset may be moderately elevated in tuber culosis of the hip or spine the afternoon temperature seldom exceeds 37.2 to 37 7° C (99 to 100 F) but when the knee ankle or elbow is involved the temperature is usually elevated to 38 3° to 38.8° C (101 to 102 F) Constitutional symptoms are more apparent in children than in adults In adults fever is much lower than in children moreover, in adults the disease may continue indefinitely without elevation of temperature unless complicated by secondary infection

The most frequent complications are tuberculous abscess pulmonary tuberculosis tuberculous meningitis and secondary infection with pyogenic organisms Abscesses when deep may be evidenced by a slight increase in temperature and may cause symptoms by mechanical pressure according to their location Secondary infection is the most common late complication, being the cause of high temperature night sweats excessive loss of weight and often death by the synergetic ac tion of pyogenic bacteria and the *Bacillus tuberculosis* Amyloid degen eration of the liver spleen and other viscera is a sequence of prolonged sepsis

Diagnosis.—The characteristics of tuberculous joint disease are chronicity and bone destruction with but slight tendency to new bone formation The diagnosis can often, but not always be made by the symptoms and physical examination There are no abnormal changes in the blood which are of diagnostic value except that a high cell count differentiates or indicates a secondary pyogenic infection The von Pirquet skin test is of value in children under twelve years of age and is of greater significance when negative than when positive, as a large percentage of apparently normal persons give a positive reaction The

FIG. 1—Roentgenogram showing tuberculosis of wrist. Anteroposterior view Note osteoporosis of the osseous structure and destruction of the articular surfaces of the radius and carpal bones.

FIG. 2—Same as FIG 1 Lateral view

joint fluid or material from a cold abscess may be aspirated and submitted to the laboratory for examination but the tubercle bacilli are not often easily demonstrated in the fluid Injection of the aspirated material into guinea-pigs may be made to confirm the diagnosis at the end of six weeks the guinea-pig is killed and an autopsy made to reveal any evidence of tuberculosis. This test is seldom of value in the early stage, as the organism is rarely present in the fluid until destruction begins. The test is also accurate only in proportion to the proficiency of the examining pathologist. Biopsy

is becoming more popular as a diagnostic measure and may be employed with impunity in all superficial joints such as the knee and ankle but in the light of our present knowledge it is certainly not practical in such locations as the hip and spine

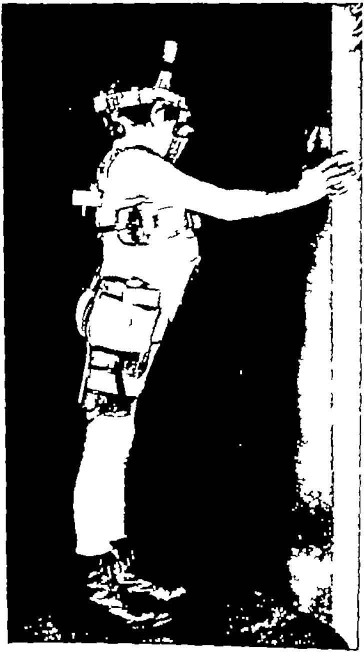

FIG. 3—Spinal brace extending from occiput to knees for tuberculosis of the spine in a young child.

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FIG. 3—Spinal brace extending from occiput to knees for tuberculosis of the spine in young child.

ROENTGENOSCOPY —In the earlier stages the roentgenogram is generally negative and is of but slight diagnostic value until there has been definite invasion of the bone The first signs noted are paleness of the osseous structure and distention of the capsule of the joint. After several months, destructive changes may be observed beneath the articular surface which is undermined Erosion of the surface is observed only after extensive invasion of the joint, and, as the process advances all parts of the joint will be destroyed In the spine, the roentgenologic demonstration of paravertebral abscess may be the first positive evidence of tuberculosis, preceding any visible change in the vertebrae although the abscess may be unrecognized in many cases The abscess appears as a spindle-shaped mass symmetrical and bilateral, surrounding the affected area of the spine. Paravertebral abscesses occur commonly in tuberculosis of the dorsal vertebrae the frequency is considerably less in the other portions of the spine. The finding of an abscess, however, is important in establishing definitely a diagnosis of spinal tuberculosis, in determining the limits of the disease, and in evaluating the progress and prognosis of the particular case.

Little or no new bone formation takes place during the repair of tuberculous joints With subsidence of the disease there is a gradual condensation of bone in the area involved and a restoration to normal osseous structure in the bone surrounding this area. After the process has entirely subsided the bone will be increased in density as compared to normal bone but the contrast is never so marked as in joints which have been infected with pyogenic organisms When sinuses and secondary infection are complications, new bone formation may be observed. Healing without infection by the production of osseous tissue is more prevalent in tuberculosis of the vertebrae than in involvement of other joints

Nonoperative Treatment.—The importance of instituting treatment as early as possible and of enforcing the necessary procedures consistently must be emphasized Tuberculosis is an evolutionary process that runs an indefinite course the length of time required for such evolution varies considerably, but all cases should be under close observation for a period of at least three years The treatment consists of local measures and constitutional therapy applied simultaneously and continuously until the disease process is arrested and encapsulated.

IMMOBILIZATION AND TRACTION —Prevention of deformity may be considered to be the keynote of orthopedic treatment. Immobilization by apparatus allays muscular spasm and relieves pain. Traction may also be applied to separate the inflamed joint surfaces. Apparatus must be employed for a long period of time It must maintain the joint in the most useful position for future function and should be so designed that it can be easily removed for heliotherapy or other light treat

ment or if not removable will not prevent the light rays from reach ing the entire surface of the body When ambulation is possible the apparatus should be constructed so as to prevent motion and the pressure from weight-bearing on the diseased joint. These measures must be strictly and continuously employed in conjunction with any and all forms of treatment for tuberculosis of joints whether constitutional or operative. In those observed in the early stage, or even in a later stage before the deformity has been fixed by strong adhesions mal position can often be corrected by special apparatus which by well directed force often combined with traction very gradually and slowly aligns the affected part in the most useful position.

Care must be exercised at all times not to induce force too rapidly *Brisement forcé* or forcible movement either with or without anesthesia, must be employed with great caution in the treatment of tuber culous joints Unfortunately this procedure is used very commonly but such practice is capable of producing serious damage Fibrous adhesions are more resistant than bony structures and therefore crushing of the atrophic extremities of the bones gross fractures and violent reaction within the joint followed by further organization and stronger adhesions may result. An even more serious contraindication is the probability of reactivating the local process causing further dis semination of the disease and resulting in disastrous complications such as tuberculous meningitis which is always fatal.

The Ankle—Conservative treatment with heliotherapy may be employed successfully in children with tuberculosis of the ankle but it is rarely practical in adults on account of the length of time required to effect results. In all affections of the foot apparatus must be employed to maintain the foot at a right angle to the leg This may be accomplished by a plaster of paris cast extending from the upper third of the leg to the tips of the toes From involun tary contraction of the tendo achillis and the force of gravity there is a constant tendency for the foot to fall into the position of equinus A common error is made by applying a cast with the foot in this posi tion, thus causing a serious complication by inducing fixed contrac ture of the tendo achillis. The cast may be bivalved so that either half may be removed without disturbing the position of the extremity when heliotherapy or other light treatment is given. Splints may be made of plaster of paris, celluloid aluminum steel or other material and when walking a brace is necessary to relieve the foot from the pressure of weight-bearing

The Knee—Orthopedic measures of fixation and traction are applied to secure and maintain the knee in extension until the disease has become arrested this requires from two to three years of continuous heliotherapy and other antituberculosis measures carefully administered. Partial immobilization correction of mild contractures and relief of pain from muscular spasm are often accomplished by traction

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Immobilization and Traction —Prevention of deformity may be considered to be the keynote of orthopedic treatment. Immobilization by apparatus allays muscular spasm and relieves pain Traction may also be applied to separate the inflamed joint surfaces. Apparatus must be employed for a long period of time It must maintain the joint in the most useful position for future function and should be so designed that it can be easily removed for heliotherapy or other light treat

the spine A plaster of paris cast or a plaster bed may be made which conforms closely to the contour of the back from the head to the tip of the sacrum. In young children ambulatory apparatus should extend from the occiput to the knees. In older children and adults, ambulatory apparatus does not need to be so extensive The Taylor spinal brace is sufficient for all lesions in the dorsal and lumbar spine below the level of the eighth dorsal vertebra When the disease process is above the sixth dorsal vertebra a head support must be attached to the spinal brace

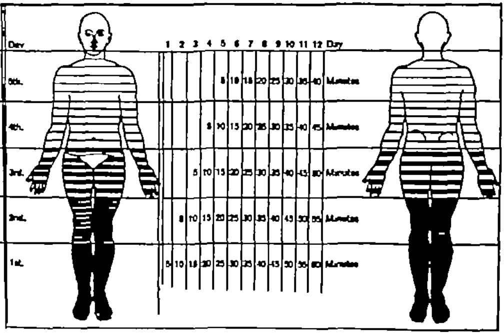

FIG. 4—Diagram t show the increase of exposure first twelve days.

The Shoulder—Tuberculosis of the joints of the upper extremity is rare especially in children and the treatment is generally conservative. The joints should be immobilized in the position most useful for function. The most serviceable position for the shoulder is about 140 degrees flexion slight internal rotation and 135 degrees abduction This position can be secured by a plaster of paris cast applied to the extremity and body and extending to the iliac crests so as to obtain firm support. The elbow and wrist are usually immobilized as well but the cast should not extend beyond the metacarpophalangeal joints in order to permit free motion of the fingers The cast may be bivalved for heliotherapy The position may be maintained also by a metal splint or a leather corset which includes the arm forearm, shoulder and thorax.

which is secured by a weight and pulley—the well known Buck's extension The extension at all times must be in a direct line with the leg when deformity is present, the pull should be begun in the angle of deformity and the apparatus adjusted as the deformity is corrected. The most efficient means of immobilizing the knee is a plaster cast which should extend from above the iliac crest to the toes Splints of various types may be employed the most satisfactory of which is the Thomas knee splint. This appliance with minor modifications may be used for the purpose of fixation and fixed traction during recumbency for fixation as an ambulatory splint and for ambulation with stilting and partial weight bearing by attaching the lateral bars to the shoe by means of a steel stirrup or, preferably, a caliper joint Apparatus must not be discarded until the roentgenogram demonstrates complete organization of the osseous union, during which time physical therapy should be employed routinely

The Hip—If efficient orthopedic measures are instituted early and maintained throughout the active stage the destructive process is restricted The hip should be maintained in the most useful position for future function Traction by Buck s extension may be instituted the traction force being applied in the position of deformity and adjusted as the malposition is reduced Apparatus to immobilize the hip must extend from the nipple line to the toes on the affected side and in most instances the opposite thigh must also be included Fixation may be secured by a bivalved plaster of paris cast or some modification of the Thomas hip splint. The caliper brace is employed frequently as a convalescent measure in affections of the hip joint, to prevent weight bearing

The Spine—Immobilization of each region of the spine presents a different mechanical problem However certain principles applicable to the entire spine will be considered with such variations as are required in the separate regions The spine should be maintained in hyperextension as pathologic processes in all regions more frequently invade the bodies of the vertebrae when there is loss in continuity of bone in the vertebral body there is a tendency toward flexion of the spine by gravity or muscular pull resulting in kyphosis In affections of the upper third of the spine, the weight of the head is an important factor and apparatus for the purpose of fixation must also relieve or support the superincumbent weight of the head In the lower lumbar spine, fixation cannot always be secured without including one or both hips

When the process is acute recumbency with spinal fixation is necessary and must sometimes be continued for one or two years For this purpose the patient is placed upon a Bradford frame and traction to the head is applied to overcome muscle spasm when the cervical or upper dorsal regions are affected traction to the legs is applied when the lower dorsal or lumbar regions are involved. The frame may be curved at the level of the disease process to enforce hyperextension of

on windows to protect smallpox patients against pitting was revived by Niels Finsen in 1893 The study of this problem led indirectly to the use of light for treating lupus rodent ulcer and tuberculosis and resulted in the founding of the Finsen Light Institute at Copenhagen.

In 1902 Bernhard noticed that meat exposed to sunlight at high altitudes did not putrefy This observation led to the resumption of the treatment of surgical wounds with sunlight. The following year (1903) Rollier opened the Sun Cure Institute at Leysin Switzerland and placed heliotherapy upon a systematic and scientific basis

The energy which is emitted from the sun consists of a series of frequencies which are measured in hypothetical wavelengths in terms of units of the metric system The rays travel in straight lines at constant speed but they vary in wavelengths The shortest visible rays are the blue and violet and beyond them are the shorter invisible ultraviolet rays or chemical rays Beyond these again are the still shorter roentgen rays and the gamma rays of radium. The shortest and the most recently discovered are the cosmic rays supposedly generated by the synthesis of helium from hydrogen The longest rays that are visible are the red rays beyond which are the longer invisible infra red rays or heat waves which comprise radiant heat The longest known group of rays are the hertzian or electric rays which measure up to one thousand feet in length and which are used at the present time primarily as carriers in wireless telegraphy Sunlight acts on the organs of sight and has the three properties of heat production light production and chemical action All wavelengths appear to possess some light and heat properties and the ability to influence chemical reactions As a rule however heat production is chiefly associated with the infra red and red rays The visible rays from red to violet differ from the rest chiefly by reason of their visibility while the most active rays chemically are the ultraviolet.

Rollier regards the ultraviolet or actinic rays as the curative agent in tuberculosis and calls attention to the fact that all parts of the spectrum (red orange yellow green blue indigo and violet) as well as the invisible rays are more intense at high altitudes and that seasonal variations in the width of the spectrum are not so marked as in low lands. Such variations he thinks are due to the formation of ammonia and nitrous compounds in the atmosphere from electrical phenomena, especially in the warmer months The invisible rays are contracted and the effects of the solar treatment are thus decreased in summer in winter there are few sunny days in the low countries and the cold damp atmosphere, with excessive wind currents does not permit general exposure On the other hand at high altitudes there is less seasonal variation in the spectrum there are more sunny days and the air is pure still and dry permitting almost continuous insolation Other authorities have demonstrated that equally satisfactory results can be obtained at any level and in many portions of America heliotherapy can be given for at least nine months of the year

The Elbow—The most serviceable position for an elbow is that which places the forearm at slightly less than a right angle to the arm with the forearm in supination or in the midposition between supination and pronation. A plaster cast for immobilizing the elbow in this position should extend from the metacarpophalangeal joints to as high in the axilla as is possible or consistent with the comfort of the patient The cast may be bivalved or the posterior half may be used as a splint.

Splints conforming to the anterior or posterior surfaces of the extremity may be employed, but the posterior splint is more efficient and comfortable. This apparatus consists of an arm and forearm piece conforming to the posterior surfaces of the hand forearm and arm from the metacarpophalangeal joints to a point on the arm at a level with the posterior axillary fold As the forearm normally is in the position of about 15 degrees valgus as related to the arm, the forearm piece on the splint must be joined to the arm piece at a corresponding angle.

The Wrist—The most serviceable position for the wrist joint is extension or dorsiflexion for in affections of this joint there is an ever present tendency toward palmar flexion and luxation Plaster casts may be employed to prevent this deformity, or a simple splint made of sheet metal called the cock up splint may also be used This splint should extend from the middle of the palm to the upper third of the forearm. A notch should be cut over the palm to allow for the adducted position of the thumb and the thenar eminence. At the wrist joint the splint is bent backward or cocked up to hold the hand in the desired degree of dorsiflexion or extension

Heliotherapy —The beneficial effects of the sun's rays upon disease processes have been recognized since ancient times, the first person on record to employ radiation in treatment was John Gadsden who treated smallpox patients, in the thirteenth century, with red light to prevent scarring. The treatment of ulcers by sunlight was undertaken by Faure in 1774 and of wounds and inflammations by Le Peyre and Le Comte in 1776 The application of this method of treatment to tuberculosis was probably first made on a rational scale by Bonnet of Lyons in 1845 This practice seems to have been discontinued soon afterward, but the physical basis of light and its chemical and biologic actions continued to be the subject of investigation of numerous scientists. Charcot, in 1859 showed that the effect of sunlight on the skin was not dependent upon the heat rays and, therefore must be due to the ultraviolet rays In 1877 Downes and Blunt published the results of experiments in which a beam of light was dispersed with a prism and the various portions were allowed to fall on plated cultures of bacteria proving that light retards the growth of bacteria and furthermore, that the shortest exposures necessary are in the ultraviolet region The use of red shades

circulation. The appetite is improved and the digestive functions are more normal The metabolism is also accelerated although this is probably due not to light action alone but to the coincident exposure to fresh outdoor air It has been shown that the blood platelets if low in number may at times be markedly increased by ultraviolet radiation the lymphocytes may also be increased The erythrocytes and hemoglobin are probably not increased by light alone altitude playing an important rôle in their production. Increase in the red cells and hemoglobin however has been observed constantly in patients treated by heliotherapy at Memphis Tenn where the elevation is approximately 300 feet above sea level.

Technic.—Heliotherapy can be given to better advantage in institutions especially equipped for the purpose When this is not practical instruction for several weeks in an institution will be of material advantage before treatment is begun at home which can then be carried out very effectively A place which is protected from wind currents should be selected for the treatment A southern exposure is preferable so that both morning and afternoon sunlight can be secured The location must be open above to the sunlight and not enclosed by glass metal or wire screening A cot or bed upon which the patient may lie should be provided All clothing is removed the head is covered by a broad brimmed hat and the eyes are protected from the glare of the sun by a pair of amber glasses. A sheet may be used during the first week to drape the unexposed portions of the body After tolerance to the sun has been acquired a T-strap is all that is necessary to cover the genitals If the exposure is begun in the winter a blanket should be used instead of a sheet. When the sun is very hot a damp cloth or ice-cap may be placed on the patient s head Orthopedic apparatus should be so constructed as to permit the sun s rays to reach the skin

In summer when the sun is intensely hot the exposure should be started as early as possible in the morning and should be resumed in the late afternoon omitting the midday hours In winter the best time for the exposure is in the middle of the day beginning about 10 a m The exposure should be given as nearly as possible at the same time each day When the patients are debilitated and when the weather is cool exposures are made on the first day for five minutes every two hours The feet and lower four inches of the legs are uncovered and exposed to the sunlight Both the front and back surfaces of the body should be exposed and the areas alternated by lying first on the back and then on the abdomen On the second day the feet and legs are exposed as described for the first day The sheet is then raised so that a new surface four inches above is exposed and the treatment is continued for three or five minutes longer Thus the time of exposure on the original area is increased to eight or ten inches. Both front and back surfaces of the legs should be exposed On the third day the time of exposure over the feet and legs is increased to fifteen minutes the

The physical and physiologic effects of sunlight have been studied extensively. Downes and Blunt showed that light exerts definite bactericidal action and that *the shorter light rays are easily absorbed* and produce intense hyperemia, resulting later in pigmentation. Light, in all probability, acts indirectly on the body by means of the cutaneous nerves and blood vessels, as no evidence has been advanced to show that ultraviolet radiation can penetrate into the depths of the body if employed in dosages suitable for clinical use. The hyperemia of the skin relieves the internal organs and tissues of much of their

FIG. 5—Heliotherapy at the Crippled Children's Hospital, Memphis, Tenn.

vascular contents, causing increased warmth, blood volume, and circulation through the local area. With the production of cutaneous hyperemia, there is developed a more pronounced bacteriophagic and bacteriologic action of the blood stream.

In addition to the analgesic effect of the cutaneous hyperemia, the direct action of light upon the nerve endings in the skin may also produce reflexly physiologic changes within the body. Constant exposure to sunlight induces pigmentation of the skin, stimulates the physiologic functions of the skin, and causes the skin to be more resistant to infection from without. The exposure also raises the calcium and phosphorous content of the blood, restores the natural tone of the muscles, and causes an increase in density and dimension of the osseous structure. In addition the sun treatment promotes greater respiratory activity which improves the heart action and the general

circulation. The appetite is improved and the digestive functions are more normal The metabolism is also accelerated although this is probably due not to light action alone but to the coincident exposure to fresh outdoor air It has been shown that the blood platelets if low in number may at times be markedly increased by ultraviolet radiation the lymphocytes may also be increased. The erythrocytes and hemoglobin are probably not increased by light alone altitude playing an important rôle in their production Increase in the red cells and hemoglobin however has been observed constantly in patients treated by heliotherapy at Memphis Tenn., where the elevation is approximately 300 feet above sea level

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In summer when the sun is intensely hot, the exposure should be started as early as possible in the morning and should be resumed in the late afternoon omitting the midday hours In winter the best time for the exposure is in the middle of the day beginning about 10 a.m The exposure should be given as nearly as possible at the same time each day When the patients are debilitated and when the weather is cool exposures are made on the first day for five minutes every two hours The feet and lower four inches of the legs are uncovered and exposed to the sunlight. Both the front and back surfaces of the body should be exposed and the areas alternated by lying first on the back and then on the abdomen On the second day the feet and legs are exposed as described for the first day The sheet is then raised so that a new surface four inches above is exposed and the treatment is continued for three or five minutes longer Thus the time of exposure on the original area is increased to eight or ten inches Both front and back surfaces of the legs should be exposed On the third day the time of exposure over the feet and legs is increased to fifteen minutes the

time over the second area to ten minutes, and a new surface of four inches is exposed for three or five minutes. The time and surface area on both sides of the body are gradually increased in this manner until the entire body acquires tolerance to the sun and air and the proper dosage is secured

Dosage.—As the reaction of different individuals varies no arbitrary rule can be made as to the maximum dosage, some patients will improve on ten hours daily while others can stand only six. In robust patients when the temperature is above 23 8° C (75 F), the tedious process of acquiring tolerance may be omitted and the entire body exposed for five minutes every two hours, increasing the amount from three to five minutes each day until the maximum time is reached. Especial care must be taken not to burn or blister the skin for if this occurs the treatment will not only be delayed but the patient will be discouraged and unnecessarily annoyed. If the patient has been sun burned, give a shorter exposure the next time The length of time given for exposure is for full sunshine. If the patient is exposed ten minutes on a partly cloudy day and fifteen minutes the next time on a hot sunny day, he may be burned even though the schedule is followed exactly On rainy days the sun should be utilized whenever it shines When the weather is cloudy the exposure is not so effective but should be continued routinely The length of time may be increased on cloudy days after the patient has acquired tolerance.

Heliotherapy must not be indiscriminately administered or much harm may accrue. If headache weakness, nausea or fever is present, the time of exposure should be decreased or the treatments discontinued temporarily to be resumed later and more gradually If the sun is very hot, decrease the time of exposure. Never keep the patient out if he is cold or chilly Bring him in at once and see that he is well warmed If the patient has discharging sinuses or open wounds on the body the bandages may be removed and the part exposed care being taken to keep flies away from the wound and from the soiled dressings. The discharge from sinuses is markedly increased after insolation, but later subsides and becomes less purulent as healing progresses.

Pigmentation or tanning of the skin is essential to success and synchronous with clinical improvement. Patients who pigment readily improve more rapidly than those who do not pigment and conversely response to treatment is not so satisfactory in those who do not tan or freckle, as blondes, particularly red blondes. Brunettes will become a mahogany brown the blackest negroes become a shade blacker and there is slight danger of sunburn Pigmentation is not merely a protective agent against the caustic action of the chemical rays of the spectrum, but it is an important factor in favoring penetration of light inasmuch as it changes a white reflecting surface to a dark light-absorbing one Rosselet suggests that possibly the pigment in the skin transforms the long light waves into shorter waves of deeper

penetration thereby reaching the superficial blood vessels Other authorities deny that sufficient evidence has been produced to prove that pigment transforms invisible rays into chemical rays although Mayer states that it may well allow a greater and more prolonged utilization of the visible radiations Another theory is that the pigment absorbs the visible and ultraviolet rays and converts them into heat which activates the sweat glands the sweat in turn protects the body from excessive heat by evaporation Whatever the exact mechanism is, it is well known clinically that individuals who pigment well tolerate more prolonged application of light and withstand exposure to extreme degrees of heat and cold more easily

The influence of heliotherapy on the pathologic process is demonstrated by the roentgenogram. About the time pigmentation is established there is increased activity as denoted by the breaking down of the osseous structure Later absorption of necrosed areas will be observed the affected bone becoming more opaque and after a few months exposure rapid destruction of the joint surfaces is observed By the end of six or eight months the bone is often more dense than normal with beginning fusion of the joint. The inflammatory exudate surrounding the affected areas becomes irregular and gradually diminishes in circumference or at times undergoes calcification. This rapid evolution is probably due to the removal of devitalized tissue by natural forces stimulated by the tonic action of the sun s rays and might easily be mistaken for an acute exacerbation. This hastening of the evolutionary process is also evident in those cases with secondary infection and draining sinuses the discharge of which is markedly increased after insolation but later subsides and becomes less purulent and more serous as healing progresses

The length of time required to secure satisfactory results varies but excellent results have been obtained after as short a time as five months In all tuberculous affections overtreatment is advisable. In every case at least two seasons of nine months insolation should be given but in the majority three years of continuous treatment. When the finances of the patient permit there should be a close pursuit of the sun for the entire twelve months of the year which can be acquired by moving to warmer climates as Florida, southern California or Texas during the winter season A change of climate is often more essential in bone than in pulmonary tuberculosis as many clinicians believe that climate has no influence on the latter condition.

Actinotherapy —In certain localities where the amount of sunshine is limited and during the months when direct exposure to the sun s rays is not practical, artificial heliotherapy may be employed, although the same beneficial results are not to be expected Among the various sources of artificial light are the carbon arc light the quartz mercury vapor light and the roentgen ray In deciding which is the best of these when obliged to use artificial light, either wholly or

in part, preference should be given to the light that gives a spectrum most nearly resembling that of the sun, or which exhibits the greatest number of those rays which typify the therapeutic quality of sunlight. The carbon arc light alone exhibits a continuous spectrum like that of the sun, all others showing a line spectrum—that is a spectrum con-

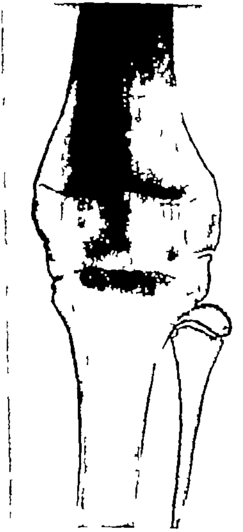

Fig. 6—Roentgenogram showing result of operative fusion of knee for tuberculosis. Anteroposterior view. Surgical treatment was employed in conjunction with heliotherapy and the disease has been completely arrested.

Fig. 7—Same as Fig. 6. Lateral view

taining luminous lines broken by dark intervals. From experiments conducted at the Finsen Medical Light Institute in Copenhagen, the carbon arc light has been proved to be the light that most nearly approaches sunlight. Not only does it exhibit a continuous spectrum rich in blue violet ultraviolet, and especially the long wave ultraviolet

rays but it is also highly efficient in both infra red and luminous red rays

The Carbon Arc Light—The light described by Strandberg and Reyn as the standard model at the Finsen Medical Light Institute is so constructed that it can carry an extremely powerful current. The power used is direct electric current of 75 amperes and the lamp requires 55 volts The carbon electrodes are very thin as it has been found that the thinner the electrodes the more intense the white light and hence the richer in chemically active rays is the light radiated from the crater which forms on the upper or positive electrode. The rays from this crater are essentially the light used and they form a cone of brilliant light under which the patient must be placed

The room in which the treatment is given should be 5.4 by 7 meters and 4 meters high. The floor should be of noninflammable material and the wall painted a dark color so that neither patient nor staff may be affected by the heat rays reflected from a light colored wall Whenever possible a skylight or other ventilating device should be arranged to carry off the heat and fumes from the lamp The windows should be constructed so that they can be opened from the top without being opened at the bottom in order to avoid drafts The lights are suspended so that the distance from the anode to the floor is about three feet. The patients are nude and are placed in a circle about the lamp being approximately four feet from the anode Their eyes should be protected by goggles with very dark amber lenses The dosage must be carefully timed and the operator should remember that lamps made by different manufacturers vary greatly in their intensity Strandberg at the Finsen Medical Light Institute recommends for adults an initial exposure of from twenty five to thirty minutes over the whole body This dose is increased by from ten to fifteen minutes every other day until the full period of two and one-half hours is reached The dosage with the American made carbon arc lamp is usually much less than that advised by Strandberg The lamp used at the North western University Medical School produces a skin erythema in one minute at a distance of four feet. In children the initial exposure must be of much shorter duration and the dosage more gradually increased When the maximum time is established this dosage should be con tinued unless the patient misses several treatments When this occurs the time of exposure on resumption of treatment should be reduced ac cording to the time lost the physical condition of the patient and the amount of pigmentation still present. As in heliotherapy treatment should be given continuously for from six months to two years

Quartz Mercury-Vapor Light—The mercury arc is especially rich in the extremely short actinic or ultraviolet rays which have a rapid germicidal action It does not however give a continuous spectrum and the long rays are entirely absent All clothing is removed from the patient and amber eyeglasses or goggles are worn to protect the eyes The patient is placed in a recumbent position and subjected

for three minutes during the first treatment to the action of the rays of the lamp, which is suspended twelve inches above the patient. As with the carbon arc lamp, it must be remembered that quartz mercury vapor lamps made by different manufacturers vary in their intensity and that the same lamp loses strength gradually with use so that when new the time of exposure must be shorter than after the lamp has been burned for a while In children, one minute with the lamp suspended 30 inches above the patient may be sufficient when using a lamp

Fig. 8—Roentgenogram of shoulder after surgical arthrodesis combined with heliotherapy The patient is well clinically

for the first time If the patient can be turned the back is also exposed to the light for a similar period of time The time of treatment is increased one to three minutes daily as the skin acquires tolerance to the rays until one hour per day is reached or pigmentation is established. As in heliotherapy improvement is synchronous with pigmentation and response to treatment is not so satisfactory in those who do not pigment or freckle. The dosage must be regulated to each individual the maximum for any patient after tolerance is acquired being six hours per day The contraindications to the use of all light

baths are severe forms of heart disease arteriosclerosis nontubercu lous nephritis gastro-intestinal disturbances and acute illnesses with a temperature of over 38 3° C (101 F) unless the cause of the fever is known and not considered to be a contraindication

Marine Treatment —Marine treatment is the routine bathing of the tuberculous patient in sea water and is of tonic value especially when combined with heliotherapy The atmosphere absorbs a certain percentage of all kinds of rays, although not an equal amount of each kind the degree of absorption being greatest in the case of the shorter waves Therefore at sea level sunlight will contain comparatively few ultraviolet rays and will contain comparatively many blue violet luminous and heat rays The effect of sunlight at the seashore however is greatly enhanced by the reflection from the white sand and from the mirror action of the surface of the water Equally good results are, therefore secured at the seashore as in the mountains

Roentgenotherapy —Treatment with the roentgen ray is con sidered by some authorities to be of value in the conservative therapy of bone and joint tuberculosis Roentgenotherapy is not a specific treatment but is considered to be successful only when there is a tendency to spontaneous recovery The results are better in diseases of the small articulations and bones than in diseases of the larger ones Tuberculosis of the toes, fingers hand foot ankle wrist, sternum and ribs is improved by this method The elbow may also be treated to ad vantage The shoulder and knee are less amenable and treatment is not so satisfactory in disease of the hip sacro-iliac articulations and spine. In treating these latter conditions deep therapy apparatus is essential Hornicke recommends in most cases one third of an ery thema dose provided that no complications are present. The number of irradiations should be so regulated that the total dose for six weeks of treatment will not exceed one erythema dose When this amount has been administered and repeated three times further treatment should be discontinued for several months The optimal dose varies in individual cases It is therefore advisable to begin with small doses and gradually to increase the amount of irradiation according to the patient s requirements and tolerance. If abscesses or fistulas are present the dosage must be smaller and more carefully regulated Over treatment may lead to rupture of the hyperemic skin over the abscess with the formation of an ulcer or the sinuses may close with con sequent retention of the pus As in the treatment of tuberculosis with heliotherapy and actinotherapy roentgenotherapy *must be combined with intensive general treatment*

Operative Treatment.—Excision of the tuberculous focus is rarely feasible even though the diseased area is small unless it is possible to excise an entire bone as for example excision of the astragalus in tu

berculosis of the ankle joint Resection of the joint for the purpose of eradication of the disease process is obsolete in both children and adults, but it is especially contraindicated in children, not only on account of affecting growth by injury or removal of the epiphyses, but because the process is very rarely arrested In adults, excision may be indicated in elbow but seldom, if ever, in other joints Unless some definite advantage is to be gained indiscriminate operations may have a deleterious effect. Definite sequestra when demonstrated by the roentgenogram may at times be removed with beneficial results, and sinuses may be excised or properly drained

Tuberculous abscesses should be treated conservatively unless rupture is inevitable or life is endangered by mechanical pressure on vital organs The treatment consists of aspiration of the abscess when fluctuation is present, after which continuous compression is made by bandages When secondary infection by pyogenic organisms is a complication, as evidenced by constitutional symptoms of high temperature and other indications of sepsis incision and drainage should be carried out along the same principles as in the treatment of pyogenic abscesses. The injection of various antiseptics into the abscess is employed routinely by many surgeons but is of doubtful efficacy Sinuses may be defined by injection of opaque substances, such as bismuth after which excision or drainage may be instituted

The purposes of surgical arthrodesis are practically the same as those of nonoperative measures—to enforce rest with fixation and to prevent deformity until nature encapsulates the pathologic process. By means of bony fusion a better fixation is secured and it has been proved by clinical experience that the arrest of the process is more apt to be permanent when osseous ankylosis results from any form of treatment. However emphasis cannot be too strongly made that conservative treatment, as mechanical fixation and all measures tending to elevate the stamina and the natural resistance of the patient must be constantly and rigidly employed both in adults and children and that fusion is only a valuable adjunct and must not be viewed in the light of a curative agent The chances of a permanent recovery are much greater when such measures as heliotherapy, proper diet, fixation by orthopedic apparatus and operative measures are combined judiciously

The indications for fusion operations vary in different joints, but at the present time arthrodesis is advised for tuberculous joints in all patients above the age of fourteen years with the exception of the elbow in which satisfactory results may be obtained by excision. In young children between the ages of three and five when tuberculous arthritis is most prevalent, the induction of intra articular fusion is difficult Time is also of less economic importance to the child than to the adult and longer periods may be devoted to conservative measures The induction of osseous fusion is influenced by the stage of the existing pathologic process The early stage, before there is extensive

destruction or osteoporosis and the late residual stage after the osseous structure has returned to normal density are the most favorable periods to induce fusion In the stage of active osseous destruction with acute symptoms often complicated by abscess the likelihood of inducing bony union is less and there is also the possibility of converting a closed tuberculous process into an open one with secondary infection Fusion in the presence of an active pyogenic secondary infection should be undertaken with great caution The probability of relighting a virulent active process even though it is apparently arrested is much greater in those in whom such secondary infection has occurred The operation may be employed also in conjunction with extra articular osteotomy for the purpose of correcting deformity when present.

Prognosis.—The time required to effect a cure naturally differs according to the severity and locality of the affection. Broadly speaking it can be stated that tuberculosis is arrested in children more quickly than in adults and that affections of the small joints are more rapidly and easily healed than those of the large joints Excellent results are sometimes obtained in six months but as a rule two years or more are required

The prognosis for recovery with a practical degree of function preserved is unfavorable and is possible theoretically only in those in whom the process is arrested and encapsulated before the joint is involved With conservative as well as with operative treatment observation is required for a period of at least three years The only definite promise to be made as to the efficiency of local treatment is that deformity can be prevented or restricted to a minimum degree and that the process will probably be arrested In those receiving no treatment, or inefficient treatment, the course is more prolonged and indefinite resulting in deformity and permanent disability The results can best be expressed as arrested instead of cured since dormant or latent foci may remain indefinitely regardless of the treatment employed

Uncontaminated tuberculosis is rarely fatal unless there is invasion of a vital center as the cerebrospinal system. Death is more frequently due to secondary infection or other complications The prognosis for life is better in children than in adults The mortality is greater in involvement of the spine and hip joint and less in the upper than in the lower extremities When abscesses are uncomplicated by secondary pyogenic infection the prognosis is very slightly affected With secondary pyogenic infection the process is much more prolonged and the prospect of recovery materially reduced Amyloid degeneration as a result of continued sepsis is usually fatal Pulmonary tuberculosis when associated lessens the chances of recovery but runs a milder course than when tuberculosis of the lungs occurs independently Tuberculous meningitis is an infrequent but fatal complication

In adults, early operative measures for the purpose of fusing or immobilizing internally the affected joint will often arrest the local process In children, there exists at present a difference of opinion as to the advisability of fusion, the preliminary reports are most encouraging but sufficient time has not elapsed for definite conclusions to be reached The scientific application of the sun's rays or artificial light should always be employed Undoubtedly, fresh air alone has a beneficial effect, but the relative improvement is much greater in those treated by heliotherapy than in those treated by fresh air without removal of the clothing The results are also more lasting with less danger of recurrence than with any other method

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CHAPTER FIVE

PHYSICAL THERAPY IN THE TREATMENT OF FRACTURES

PHILIP D WILSON, M D

INTRODUCTION

The place of physical therapy in fracture treatment has been a matter of controversy and different opinions have been expressed Some experienced surgeons consider physical treatment unnecessary or even harmful holding that only active voluntary effort on the part of the patient actually counts in restoring function Others regard physical therapy as a luxury and doubt that the possible benefits justify the expense especially in patients of moderate means Still others consider physical therapy dangerous from the psychologic stand point, in that it places undue emphasis upon the treatment of short duration administered by the technician and tends to minimize in the patient s estimation the value of his own efforts usually just at the time when active coöperation is most necessary in obtaining a good result.

On the other hand physicians who are experienced in the art of physical therapy consider it absolutely indispensable in the treatment of fractures They point to the harmful effects of treatment by im mobilization alone as evidenced by the many patients with impaired function who drift into their hands many months after injury having been treated by every method except physical therapy They criticize the neglect of many physicians to consider the physiologic require-ments of the muscles the joints and the circulation and for believing that the only indications for the treatment of fractures are complete reduction and prolonged fixation. They feel that a considerable propor tion of fractures can be treated by physical therapy alone and with vastly better results than frequently are obtained by physicians who place their reliance entirely upon retentive apparatus.

In between these extreme views may be found all shades of opinion in respect to the value of physical therapy in fracture treatment. For the most part however the rank and file of the medical profession are unable to form an opinion and admit a complete lack of knowledge In the minds of most of these the term *physical therapy* evokes the picture of an establishment fitted up with a large assortment of com plicated electrical machines variously colored lamps and hydrothera peutic apparatus They feel vaguely that all of this machinery may

have some therapeutic value, but mistrust it for their patients on the grounds of expense, inability to direct the treatment, and the belief that after all it is not necessary They are unable to dissociate the ideas of physical therapy electricity and machinery For the most part, they do not employ physical therapy for the treatment of frac tures except when usually as the result of some fault of treatment, a patient has obtained an unsatisfactory result, and nothing else in the way of treatment remains to be tried

The student who is seeking the truth about the value of physical therapy in fractures will quickly dismiss many criticisms that obviously proceed from ignorance. On the other hand, he will not be able to dispose in this summary fashion of the widely divergent opinions that have been expressed by experienced and reputable surgeons and physical therapists. If he delves more deeply into the subject, however he will find that it is possible to reconcile even these differences and that the opponents are in reality proceeding from different premises and arguing about different things The physical therapist shares with the surgeon his high estimate of the value of active voluntary effort in regaining function at a certain stage of fracture treatment, but he also knows that if he waits until the time when active motion can be performed, to employ physical therapy he will have missed the golden moment for helping the patient The surgeon is sceptical of the value of physical therapy chiefly because he has never used it until after consolidation of the fracture has been obtained and the physical therapist would be the first to admit that it can accomplish little at this time and should not be used except in so far as to teach the patient how to help himself by active exercises The two methods are complementary not competitive. When the physical therapist advocates massage and mobilization of the fresh fracture he is speaking of a highly special ized technic totally different from the deep massage and vigorous movements that the surgeon has in mind The surgeon labors under the impression that early physical therapy means turning over for treat ment, by mere technicians patients with loose, freshly reduced frac tures whereas the physical therapist has in mind only that many frac tures are susceptible of treatment by this method that the surgeon should learn to apply this specialized technic himself and that it should be stored in his armamentarium along with the other tools of his trade to be used according to the indications of the individual case

Much of the criticism of physical therapy arises from a failure to distinguish between the agency itself and its use. Physical therapy can be of great value in the treatment of fractures when properly em ployed of that there is ample proof It can likewise do harm when improperly used It can also fail to be of any benefit whatever when employed at the wrong time Physical therapy has frequently been misused in the treatment of fractures but instead of reacting to the detriment of physical therapy this should serve as a stimulus for acquiring sufficient knowledge of the art to be able to employ it

properly No physician who treats fractures can really say with truth that he does not employ physical therapy The prescription of heat at one or another time in one form or another is practically universal so also with home massage and exercise By so much the physician admits that he believes in physical therapy All that remains necessary to enlarge his vision of its sphere of usefulness is to inform him more specifically of the action of its various agencies and to relate these effects to the pathologic and reparative changes of fractures in so far as possible

While much of the confusion that hinders a just evaluation of physical therapy may be traced to the lack of knowledge of the physician who treats the fracture not a little arises from lack of knowledge of fractures on the part of the physical therapeutist. Many exaggerated claims have been made of the benefits to be derived from the use of various physical therapeutic agencies in the treatment of fractures which cannot possibly be substantiated. Some are the result of enthusiasm others require a less charitable explanation all bring harm to the cause of physical therapy Many agencies are used whose effects are uncertain or in respect to the action of which experimental evidence is lacking The physician who is conversant with the problems of fracture treatment and is trying to steer his patient through the shoals and troubled waters of complications to the haven of a speedy convalescence cannot be blamed for refusing to ask the assistance of a pilot who insists upon sailing only in uncharted channels.

The first principle of fracture treatment is reduction of the bony deformity and after that comes treatment to secure healing of the fracture and to restore function Of the various physical measures that are employed in treatment by far the most important are two that are mutually antagonistic—rest and movement. Rest or immobilization is necessary to maintain reduction of the fracture and allow healing of the bones while equally necessary from the standpoint of the muscles joints blood vessels and nerves is movement or mobilization to maintain and restore function Indeed in the balancing of these two antagonistic principles lies the essence of fracture treatment and it is because the requirements are of a conflicting nature that difficulty arises Between the moment when the first cautious attempts at movement are begun in a recently reduced fracture and the later period when healing of the bones has been obtained and vigorous exercises can be prescribed lies an interval often of many weeks during which every detail of treatment must be managed with skill and when any ill considered step may bring disaster It is not possible during this period to turn the patient over to a technician for physical therapy without endangering the result, and it is unwise to do it later unless the physician supervises the treatment in the closest manner In the treatment of fractures it is impossible to separate the physician and the physical therapist He will be the best physician who is instructed in the art of physical therapy and the best physical therapist will be he

who combines this knowledge with that of the physician Indeed if physical therapy is to accomplish anything in the treatment of fractures, it will be because the physician is sufficiently impressed with its value to administer it personally in the first few days after injury, and to instruct and demonstrate to his assistants the methods he wishes to have followed in the later stages

Physical therapy includes a number of agencies or modalities, each of which is capable of producing a definite physiologic reaction in the human body In order to employ these successfully in the treatment of fractures the physician must know what these agencies are, what they accomplish and when they can be used with benefit. He must be able to prescribe them in the same manner as he does drugs When a physician prescribes medicines, he not only writes his prescription carefully but he takes pains to refer the patient to a reputable pharmacy to have it filled. He instructs the patient how frequently and in what amount he is to take the medicine and he arranges to have him report at regular periods in order to be able to watch his reaction and to modify the dosage if the reaction is unfavorable or to stop the treatment altogether if it proves to be of no benefit. The same course should be followed when prescribing physical therapy the treatment should be outlined in detail, and the directions followed minutely When in doubt, consultation between the physician and physical therapist will prove of great benefit. To send the patient to a physical therapist with instructions merely to treat him, as is frequently done at present, is in principle almost as ridiculous as to refer a patient to a pharmacist with instructions to prescribe what medicines he needs.

It will be the purpose of the author in this article to point out the opportunities for physical therapy in the treatment of fractures, to show how fracture pathology may be modified by the physiologic reaction to the agencies that are employed, to stress the importance of early functional activity and to demonstrate how this may be obtained. Chief emphasis will be laid upon the various forms of massage and mobilization with the view to confining the discussion to those agencies of which we have the most knowledge Of the various methods of electrical stimulation and treatment there will be but little mention, as too little experience has yet been acquired to make it possible to formulate directions for their use or to permit definite conclusions to be drawn as to their value

Historical

Just Lucas-Championnière was the pioneer of physical therapy in the treatment of fractures. A surgeon practicing in the hospitals of Paris he became dissatisfied with the results obtained by the routine methods for treating bony injuries The central principle around which these methods revolved was immobilization, and the more perfect the immobilization the better was the treatment. Lucas-Championnière however observed that the patients who had been treated by these

methods kept coming back to the clinics for months and years complaining of swollen limbs stiff joints pain and disability even though their fractures had healed He recognized that much of this was the result of prolonged fixation and the policy of treating the fracture as if the bone were the only constituent of the part and the muscles joints vessels and nerves nonexistent.

He began experimenting with massage and movement in the treatment of recent fractures commencing with minor bony injuries such as those involving the shaft of the fibula and then gradually as he perfected the technic and gained confidence in the method extending it to fractures involving more important bones as well He found that with gentle stroking massage he could relieve pain even in the fresh fracture and secure muscular relaxation with care, the joints adjacent to the fracture could then be moved passively through a wide arc of motion without causing pain With regular repetition of these treatments the part being splinted during the intervening periods the patients recovered from their fractures more quickly and more completely than others whose fractures had been completely immobilized. When he extended the scope of the method to include more difficult fractures such as those involving the lower end of the radius and the upper end of the humerus the results proved equally impressive It became quite obvious to him that early movement of the muscles and joints in the vicinity of a fracture maintained their suppleness on the one hand and on the other favored the circulation and nutrition of the member He became convinced of the importance of early massage and mobilization in the treatment of fractures

Lucas-Championnière [1] published in 1889 a small pamphlet entitled "Le Massage et la Mobilization dans le traitement des Fractures in which he summarized his experiences and observations and described the methods that he employed and their rationale He considered mobilization the most important factor of this treatment. Referring to a limb he said movement is life He believed that massage was merely a means to an end that end being movement. He employed only the gentlest type of superficial massage and the treatment was administered either by himself personally or by a medical student whom he had trained Avoidance of pain was deemed essential The massage brought about relief of pain and relaxation of muscle spasm Its effects could not be explained upon mechanical grounds as the massage was too light and superficial in character and he advanced the theory that it acted reflexly through the nerves and that it brought about an exhaustion of the sensory endings The massage was administered for from ten to twenty minutes and, when muscular relaxation had been obtained then mobilization of the neighboring joints was in order The movements were performed passively not actively but only when the muscles were completely relaxed The treatments were of short duration and were repeated daily or on alternate days

The results obtained by Lucas-Championnière were remarkable par

ticularly in contrast with those obtained by the preëxisting treatment. In judging these results, however, it is well to remember that this was prior to the discovery and clinical application of the roentgen ray, and that the diagnosis of fracture was often faulty, and the control of reduction negligible Bony deformity of greater or lesser degree was the rule rather than the exception after treatment. Lucas-Championnière s treatment probably did not lessen the bony deformity, but it did at least restore function and in this respect it was far and away ahead of the usual immobilizing treatment. At the same time there has been a great misconception of his real attitude While radical, he never took an extreme stand or claimed that his treatment could be applied without modification to every fracture or that all splinting should henceforth be discarded He did not discard all that he had learned in his surgical training, but on the contrary continued to use splints in loose and displaced fractures and to advocate operative repair in fractures, such as those of the patella where that method obtained the best results. Only instead of making the fixation continuous as was the general practice he removed the splints at regular intervals for massage and mobilization Above all, it must be remembered that he kept the treatment entirely in his own skilled surgical hands or in the hands of the medical students whom he himself had trained He had no use for massage as ordinarily practiced, which he considered far too vigorous and painful, nor did he think it possible for even a trained technician to employ his methods satisfactorily What he advocated was the early use of physical therapy—i.e., massage and mobilization—by the physician in charge of the patient, in conjunction with whatever other methods were indicated for the reduction and healing of the fracture

While holding up a warning hand against the treatment of fractures by prolonged immobilization he at the same time sounded a warning note against the injudicious and uninstructed use of his methods which should be read carefully by any one who is tempted to be led away by enthusiasm for any particular method of treatment. Said he 'It is a serious matter to employ this revolutionary treatment, for the public is but little prepared to accept it and the medical world is even less prepared than the public. I advise you therefore to act prudently, and to advance only by sure steps in order not to expose yourself to checks to apply the method in such a manner that the good which may result therefrom will be evident to all.

Lucas-Championnière s work proved a turning point in the treatment of fractures The importance of functional restoration began to be recognized and with this the necessity of treating all of the structures affected by the injury rather than the broken bone alone Owing to the general misconception of what his attitude actually was only a few physicians took up and applied his methods in their entirety, although few

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of London learned Lucas Championnière's methods at first hand and has continued to employ them and to advocate them with the conviction born of a long and rich experience His works on massage and the treatment of fractures are valuable contributions deserving the most careful study I gratefully acknowledge my own indebtedness to them in the preparation of this article

Other factors also have contributed their share toward placing emphasis upon functional recovery after fractures. The Industrial Compensation Laws have played a considerable part by bringing pressure to bear on reducing the disability period for various injuries The Great War contributed a great deal to the improvement of methods for the treatment of fractures more notably by the introduction of various types of open splints and the greater utilization of traction methods particularly direct skeletal traction It also aided the development of physical therapy the accomplishments of which were seen and appreciated Since the war the multiplication of the automobile and the increasing mechanization of industry have caused a formidable increase in the number of injuries This has led to an intensified study of the means of reducing functional impairment after fractures and of securing maximum physical rehabilitation of the injured Physicians are turning their attention to physical therapy in the hope of bettering their results with help from this source. There are great opportunities for the development of this art, provided that each step is made with caution and based upon a solid foundation.

Functional Restoration the Goal of Fracture Treatment

The goal of all fracture treatment is the complete restoration of function in the injured part in the shortest possible time When the injury is of a nature to cause irreparable damage, then the aim must be to minimize the functional loss and particularly to try to avoid disabilities of a type to prevent return to the previous major occupation or activity A perfect result implies that the injured part is as good as before injury and that this has been attained without unnecessary loss of time

The chief purpose of the skeleton is to provide a rigid framework for the soft parts and together with the joints to provide a mechanism which may be actuated by the neuromuscular apparatus Interruption of the skeletal rigidity by a fracture leads to immediate loss of function and function cannot be regained until rigidity has been restored by healing of the fracture Restoration of skeletal rigidity is not alone sufficient but there must also be restoration of the skeletal form in other words the normal alignment of the bone must be preserved This is necessary not only for esthetic reasons but in order to maintain the normal anatomic relationship or architectural pattern without which the parts function imperfectly The restoration of rigidity and normal form of the skeleton however, is by no means all in the

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veins is stopped by the pressure of exudate and there is a further *accumulation of serum and lymph over a large area. Many of the* phenomena are of reflex origin as for example the edema from vasomotor paralysis and the muscle spasm with pain and limitation of joint movement. Blood clot forms about and between the ends of the bones and infiltrates all the adjacent soft parts extending into the muscles and upward and downward along the fascial planes. Unclotted blood and serum gradually work their way to the surface accounting for the extensive ecchymosis that is always seen in the region of a fracture The formation of skin blebs is due to the vasomotor paralysis and the exudation of serum and lymph.

It needs to be emphasized that this condition of traumatic inflammation is not followed by repair but actually constitutes the first step in that process Repair begins at the moment of injury The blood clot filling the spaces between the bone ends and extending into and infil trating all of the soft structures is soon invaded by leukocytes, fibroblasts and newly formed capillaries originating from all the different types of tissue involved in the injury and becomes transformed into granulation tissue It is important to note that at this stage there is apparently no difference in the character of the granulation tissue found between the bone ends and that formed in the soft tissues they are one and continuous Differentiation occurs later when calcium salts are deposited in the tissue that is destined to become callus and con nective tissue fibrils form in the intercellular spaces of that which is to become scar tissue but even then the callus and scar remain firmly bound to each other The scar formation and fixation of the muscles to the callus interfere with the contraction and extension of *the various muscles and hinder function.*

The old conception of a specific osteogenic cell the osteoblast, derived entirely from other similar osteoblasts contained in the cellular space and marrow cavities of the ends of the broken bones has lost ground According to modern views bone is merely a form of con *nective tissue and the osteoblast is simply a fibroblast in* whose vicinity calcium salts have been deposited [5] Furthermore the bone-forming function of the osteoblast has been denied It is claimed that the deposition of calcium salts in callus is entirely a physicochemical reaction dependent upon local factors as for example a variation of the hydrogen *ion concentration in that* region or a concentration of some catalytic agent or enzyme such as perhaps the recently discov ered phosphotase of Robison [6] Evidence to this effect has been produced by Murray [7] who succeeded in obtaining bone formation in muscle and fascia by the injection of certain salts of calcium and phosphorus *This evidence* has been reënforced by the experiments of Huggins [8] who was able to produce bone in the soft tissues by the transplantation of bladder epithelium

treatment of fractures Of equal importance for functional performance are the soft parts The skeleton is only one part of the machine, the other parts being represented by the articulations muscles, nerves and blood vessels Without the joints to supply motion, the muscles power the nerves control, the blood vessels fuel, the bones are merely so many inanimate levers All participate in functional activity, and one structure is not of greater importance than any other All must be considered in treatment.

Injury of the Soft Parts Accompanying Fractures

It is a common mistake in treating fractures to think only of the injury to the bone, and to forget or overlook the always-accompanying injury to the soft parts To fracture a bone requires a considerable amount of force The violence may act directly in the form of a blow or crush, in which case the first effect of the force is expended upon the soft structures before reaching the bones, or it may act indirectly as by bending or twisting a part beyond its normal limits of elasticity, in which instance the giving way of the bone is accompanied by laceration of the overlying soft parts Also severe strain is often imparted to the ligaments sometimes at a point quite remote from the fracture. When the violence is severe enough not only to fracture the bone but to displace the fragments additional damage is done to the soft parts by the temporary continuance of the force after the resistance of the bone has been overcome An extreme example of such violence is seen in the case of a compound fracture. Here the overlying soft parts are completely ruptured including the skin and one can readily appraise the extent of the damage to the muscle and other soft tissues. In the majority of fractures that are classed as simple the soft-part injury is just as great, though concealed from one s eyes by the fact that the integument remains intact. There is extensive laceration of soft parts including muscles, blood vessels and fascia. In certain instances either the main nerve or blood vessels may be torn, or both at the same time, resulting perhaps in paralysis, partial or complete ischemia, or gangrene.

Pathology and Repair of a Fracture

The key to the understanding of fracture treatment lies in a knowledge of the pathology of the lesion and of the changes that occur during the process of repair [4] When a bone is broken a condition of traumatic inflammation is produced Hemorrhage occurs from the torn vessels of the bone marrow periosteum and adjacent soft parts The blood vessels dilate as a result of vasomotor paralysis and lymphatic drainage is arrested. The swelling due to hemorrhage is further increased by exudation The return of venous blood in the unruptured

Principles of Fracture Treatment

The requirements for fracture treatment are complex and difficult to fulfill The ideal treatment could only be attained by a miracle which without the necessity of any surgical intervention would restore the displaced fragments to normal position immediately after the injury would maintain them in perfect alignment without the use of splints or other apparatus and so solidly that healing would proceed while at the same time full use of the part with motion of the adjacent articulations could be permitted. This represents an ideal impossible of attainment, but it also gives us a goal at which to aim and the more nearly our treatment can approach it the better it will be

The chief principles of fracture treatment may be stated as follows first restoration of anatomic form as soon as possible after injury second maintenance of alignment and fixation of the fracture during the period of healing third institution of measures to overcome the circulatory disturbance and to maintain and develop function beginning at the earliest possible moment after injury and continuing until complete recovery is obtained

Importance of Reduction of the Fracture

Restoration of a fractured bone to its normal anatomic form is essential to good functional recovery Not only is it true that fractures which are properly reduced unite more surely and rapidly than those that are allowed to remain in vicious alignment, but the condition of the adjacent soft parts is also improved and there is commonly to be noted less swelling and circulatory disturbance Since the traumatic inflammatory process that is initiated by a fracture reaches its peak within 48 hours it is evident that the pathologic changes can be influenced only when the reduction is performed within a few hours of injury As a matter of fact, reduction becomes increasingly difficult with every hour that elapses The muscles and fascia become infiltrated with exudate and rapidly lose their extensibility the tissue spaces become filled with lymph and fibrin and blood clot envelops the ends of the bones and renders almost impossible the meshing of interlocking fragments. The use of more force is necessary to accomplish reduction and this causes fresh hemorrhage and additional trauma to the soft parts When the changes have progressed to the stage of organization or beginning callus formation before reposition of the fragments is accomplished then still greater force must be used and the amount of damage done is proportionately increased Repeated reductions necessitated by the failure of previous attempts are enormously harmful and result in an extension of the inflammatory changes and an increase in the severity of the reaction To promote functional recovery it is of the highest importance to employ every measure that tends to minimize injury of the soft parts and to reduce cicatrization and cir

The calcium salts that are deposited in callus seem to be derived chiefly from local sources, from the autolysis of necrosed bone at the ends of the broken fragments Evidences of rarefaction and absorption here are the signs of normal progress of the healing process. For practical purposes the amount of calcium salts derived from the blood stream is relatively small and unimportant. The effect of this concept is to reduce fracture healing to a purely local process, the success of which is dependent upon local factors and only slightly affected by the general physiology of the body or by states of the body If true, as appears probable, then this view eliminates the long list of general causes that have always been brought forward in explanation of nonunion and renders superfluous therapeutic procedures directed toward improving calcium metabolism

Whatever may ultimately be proved to be the fact, the granulation-tissue mass between and about the bone ends gradually becomes converted into osteoid tissue The intercellular spaces become filled with a homogeneous ground substance, the preosseous tissue while scattered here and there are small islands of cartilage Gradually calcium salts are deposited in the ground substance and cartilage and the callus becomes hard. Bone tissue has been formed, and the union of the fracture is complete.

The time required for fracture healing is usually from three to eight weeks depending upon the bone involved and the situation of the fracture in respect to cancellous or cortical bone. The process is quicker in children than in adults, and somewhat slower in old age. Callus formation may be delayed by local conditions which hinder the formation of granulation tissue such as lack of surrounding structures from which it may spring as in fractures of the neck of the femur and of the carpal scaphoid or interference with proper blood supply or interposition of muscle tissue between the fragments Operative interference at a late period when the soft callus has to be cleared away in order to secure approximation of the fragments, is also likely to delay healing. There is considerable variation in the local conditions upon which callus formation depends between fractures of similar type in different individuals and it is not remarkable therefore that considerable variation in the healing time should be encountered The fact that union has not been obtained at the time it is expected is not a sign that it will not occur but may merely indicate that the process of repair is proceeding more slowly than at other times. The amount of callus formed at first is excessive but after the union has become solid a further process of physiologic adaptation takes place By revascularization and absorption the medullary cavity is finally reëstablished the cortical layers demarcated, and the excess callus removed. The process of physiologic adaptation of the callus and restoration of bony contour is slow and may take as long as one or two years Physiologic healing cannot be considered complete until this time has elapsed, even though anatomic healing has been obtained in a matter of weeks.

union Each fracture must be visualized in terms of its eventual end-result and the course chosen that will give the highest yield in terms of function Impaction is a start already made in the healing of a fracture and it should not be broken up without good cause especially in aged patients It is often the acme of wisdom to be satisfied with an incomplete reduction as long as the misalignment is slight and not of a disabling type rather than to pursue anatomic perfection at the cost of diminished or delayed function

Reduction may be accomplished by manipulation traction or operation With the manipulative method the operator endeavors to replace the fragments by leverage angulation or traction relying upon manual skill supplemented occasionally by the temporary use of some mechanical appliance to exert traction. When reduction has been accomplished splints are applied to maintain the alignment. Obviously the method is limited in its application to fractures that are more or less transverse and only slightly comminuted and where reposition is likely to prove stable when obtained. It is employed particularly in fractures of the wrist forearm elbow ankle lower leg and hip It is most successful when performed within two or three hours of the injury and with the aid of fluoroscopic visualization of the fractured bones It requires skill and care to avoid injury of the soft parts from the use of too much force

The traction method is used both to obtain reduction and to maintain alignment afterwards It counteracts the deforming influence of muscular contraction and by pulling the fractured bone out to full length and restoring the supporting tension of the soft parts secures correction of the deformity It should be employed in such a way as to obtain reduction immediately before pathologic changes in the region of the fracture have progressed to a stage to render it difficult, instead of gradually over a period of several days. A traction force of sufficient amount to accomplish reposition should be applied initially and after reduction has been accomplished this may be reduced to the lesser quantity necessary to maintain alignment. The same principle should be applied irrespective of what method of traction is employed or whether used in combination with traction splints or not The traction method of reduction is used chiefly in fractures of the long bones such as the femur both bones of the lower leg the forearm and humerus It is indicated in oblique and comminuted fractures involving the articulations and those of the phalanges It is also of great assistance in difficult fractures which for one reason or another have not been reduced in the early period. Traction is not without danger but it usually accomplishes its purpose with less damage to the soft structures than either of the other methods

The operative method of reduction may be employed primarily in certain fractures such as those of the patella and olecranon where approximation cannot be secured in any other way It may be employed as a matter of preference in other fractures such as those of the shaft

culatory disturbance in the region of the fracture, and for this, nothing is more effective than early reduction

When fractures are allowed to heal without correction of the bony deformity excess callus formation usually results accompanied by greater fibrous fixation of the muscles If the fracture is situated in the vicinity of, or involves a joint bony irregularity may block motion or alter articular contour sufficiently to render its use difficult Malunion also leads to later functional impairment through its repercussion upon the mechanics of the body Angular deformity causes the adjacent joints to be thrown into abnormal relationship and results in uneven bearing and strain When healing is accompanied by overriding of the ends of the fragments, shortening of greater or lesser extent results, and this affects not only the bone but also the muscles, which almost never regain normal power The Fracture Committee of the British Medical Association * reported after a study of the late results of fractures in 1736 cases that good functional results accompanied good anatomic results in over ninety per cent of the patients Fair and even good functional results sometimes accompanied poor anatomic results, but usually only after prolonged disability time and when the particular and special types of deformity that lead to great crippling had been avoided They stated that no method, whether operative or nonoperative which did not promise a good anatomic result should be accepted as a matter of choice.

The importance of the reduction of the fracture at as early a moment as possible after injury must be accepted as a guiding principle of fracture treatment. As is the case with every rule however, there are also exceptions to this Some types of deformity are more disabling than others Angular deformity and gross displacement with overriding are particularly likely to result in functional impairment. Simple lateral displacement without shortening provided that there is sufficient contact of the bone ends to insure union is much less likely to cause disability The age of the patient also makes a difference, and more latitude may be permitted in the case of children than in adults Below the age of fourteen the growth process tends to correct errors in bony alignment, and shortening of as much as one inch in the case of the femur may be entirely corrected at the end of two years. Angular deformity is just as pernicious in children as in adults and tends to persist.

All of these factors must be taken into consideration when treating patients with fractures Complete anatomic reduction is always desirable, and no effort should be spared in obtaining this result in fresh fractures On the other hand it is easily possible to go too far in this direction. Each additional effort at reduction causes further trauma to the tissue and nullifies whatever start has been made in the process of repair Fractures that have been subjected to repeated manipulation and finally to operative reduction are apt to show functional impairment later and have a decided tendency to go on to delayed or non

mobilization unduly The physician feels that he has solved the first problem of fracture treatment and does not recognize that the second problem that of securing functional recovery confronts him im mediately

Prolonged immobilization of the fracture is harmful to the soft structures involved in the injury and lays the foundations for slow recovery or permanent functional disturbances later It has been pointed out by Drinker [10] that the accumulation of lymph in the tissues stimulates the growth of the connective tissue elements Wherever there is prolonged venous or lymphatic stasis an overgrowth of con nective tissue results Immobilization of a fracture promotes venous and lymphatic stasis by suppressing muscular contraction upon which the venous and lymphatic circulations depend Particularly is this true when the circulation has already been profoundly disturbed by the pathologic changes initiated by the injury itself and by the pressure of hemorrhage and exudate upon the uninjured vessels. Not only does the fixation of the muscles and joints interfere with the reëstablish ment of the circulation and delay the absorption of the exudative products but it favors the extensive development of scar tissue and adherence of the muscles to each other and to the bone

In addition it should be remembered that immobilization causes definite functional impairment even in the case of an uninjured healthy extremity Siegal and Sheboya, as well as other investigators going as far back as 1866 (Moll [11]) have clearly demonstrated that if the bony attachments of a skeletal muscle are left immobilized for several days so as to prevent the changes in length that normally result from spontaneous and reflex movement there occurs a fixation of the muscle at the length thus imposed upon it. If taken early this con tracture can be overcome by active or passive movement but if left untreated for some time the damage becomes irreparable This process called *myostatic contracture* by Davenport and Ransom,[12] is dependent upon intact innervation. It is a condition of permanent shortening in resting muscle which is maintained in the entire absence of nerve impulses. A muscle affected by this condition cannot extend normally neither can it contract as much as a normal muscle Microscopically such muscles show blurring of the striation mottled staining and loss of alignment of the myofibrils The muscle may become permanently damaged depending upon the period of immobilization The longer the period the greater the damage and the greater the amount of time and effort required to restore function

Immobilization also gives rise to certain phenomena in respect to the articulations The joint capsule tends to become thickened and con tracted losing some of its elasticity The synovia begins to proliferate at the edge of the articular cartilage and to spread over the peripheral margin as in pannus formation When immobilization is discontinued and function resumed the invading tissue begins to recede and the joint capsule also gradually regains its flexible characteristics To over

of the femur or humerus the bones of the leg or forearm or difficult fractures involving the articulations, on the grounds that it is likely to obtain a more perfect result than any other method Resort is also had to it when previous efforts to secure reduction by other methods have proved unsuccessful The operative method is necessitated in most compound fractures to get rid of soiled and devitalized tissue and prevent infection Depending upon the situation and type of the fracture, the operative method may aim only at securing reposition of the fragments and rely upon external fixation with splints to maintain the alignment or reduction may be combined with some form of internal fixation in the form of catgut kangaroo tendon, wire screws, nails, bone plates bands, etc. Operative reduction should be made secure and no risk taken of secondary displacement which might invalidate the entire benefit of the operation Operative reduction causes a certain damage to the soft tissues from the incision and exposure of the fracture but this damage is often less in amount than that which would be caused by closed reduction It is counterbalanced by the better reduction accomplished and the greater security that results particularly when internal fixation is used Operative reduction involves a certain risk, chiefly that of infection, and ought to be undertaken only by surgeons who have had special training for this work and who have at their command all the facilities in the way of equipment and skilled assistance that have been shown to be necessary for good results Lastly it needs to be emphasized that operative reduction is not to be regarded as a matter of last resort and deferred until all other methods have been tried This generally leads to great delay and the results will be much less beneficial than if the operation had been performed earlier The physician should determine as quickly as possible what method of reduction offers the greatest chance of success and should proceed without delay to the use of that method irrespective of whether it necessitates operation or not.

Maintenance of Alignment of a Fracture

Reduction of a fracture be it never so perfect, is of little service unless supplemented by appropriate measures to maintain the alignment afterward. This necessitates the use of external fixation either in the form of plaster-of paris casings or of splints of different materials and types with or without traction. Redisplacement of a reduced fracture represents a real disaster and the more completely the fragments are fixed the less will be the danger of such a mishap The formation of callus takes time and if the policy of fixation is relaxed for a minute until consolidation is obtained, the alignment of the fracture may be lost. Furthermore, movement of the fragments may retard healing Consequently when a fracture has been reduced and splinted and the alignment has been proved to be satisfactory by the postreduction roentgenograms there is a great tendency to prolong the im-

stimulated When a fracture of the bones of the lower leg or of the shaft of the femur fails to unite within the usual time a procedure frequently adopted is to apply a weight bearing brace and encourage use and bony union often results All of these splints and braces permit a limited amount of movement at the site of fracture and it is easy to start from this point and argue that movement stimulates fracture healing

On the other hand there are facts that point to the conclusion that when the approximation of a fracture is perfect and the fixation rigid and as complete as possible then union is much accelerated In the usual fracture the conditions are so favorable for callus formation that healing may occur even in spite of a little movement In fractures of certain bones however such as the carpal scaphoid or the neck of the femur the local conditions are unfavorable in that callus formation must proceed from intrinsic sources entirely without help from the adjacent soft structures and the blood supply to one of the fragments is scanty and frequently entirely lacking Here failure of union is the common result of failure to immobilize and all authorities agree that the more complete the immobilization the greater the chance of obtaining union Turning to fractures in other regions it is not difficult to find many examples of nonunion where the responsibility can be traced directly to the door of repeated manipulations or of too much movement. While fractures of the long bones in both animals and men may heal without immobilization it is to be noted that this is accompanied by bony deformity with overriding of the fragments When displacement of a fracture is allowed to proceed without interference the shortening finally reaches a maximum and the fragments arrive at a point of relative stabilization In this position but not without it, is healing likely to take place Such a result is not likely to be accepted willingly by the average patient and to obtain healing without deformity the wise physician will always employ immobilization. Similarly the explanation of the benefits that result from the use of weight bearing splints or braces in fractures of the lower extremity is to be found in the improvement of the circulation and the overcoming of bone atrophy which counterbalance and outweigh the harmful effects of such slight movement as cannot be prevented at the site of fracture

One must conclude from a review of all the evidence that rigid immobilization of the fracture with good approximation accelerates bony union but that on the other hand callus will usually form even in spite of a little motion of the fracture With the microscopic picture of bone repair before one s eyes it is easy to understand that movement of the fragments while the callus is soft and in a formative stage is likely to result in rupture of many of the small vessels and lead to an increase of the connective tissue elements which may be harmful later to union If any motion is to be permitted during the healing of a fracture it must be reduced to the very minimum.

come and counteract these changes a considerable amount of time is required, during this period use of the part is painful, and progress is likely to be delayed unless the patient exhibits considerable fortitude.

These are only a few of the more definite effects of immobilization upon the muscles and joints, and other examples of harmful results pertaining to the circulation and disuse atrophy of muscles and bone might also be given if it were necessary to make the picture complete. Enough has been written however, to show the importance of avoiding complete immobilization of a fracture, whenever possible, and of reducing the period of fixation to the shortest possible time when no other method can be used

One other question arises in connection with the subject of immobilization namely whether it is necessary in order to obtain healing of the bone In the animal world there are found many examples of fractures that have healed without immobilization Indeed, among the wild animals scarcely any other outcome after bony injury is possible save death. An animal that has fractured one leg keeps going on the remaining three legs until such time as the injured part has mended sufficiently to permit of some use Necessarily gross deformity results from such treatment or lack of treatment but this does not prevent callus formation as is shown by the observation of many game hunters and other students of animal life nor according to report, does it seem to interfere very seriously with the function of the part. The situation with regard to the human animal is of course, much more complex, but unfortunately examples are not lacking to show that unrecognized and untreated fractures may go on to union with deformity Lucas-Championnière [18] called attention to the fact that callus formation almost never failed in the repair of fractures of the ribs and yet that these bones were never completely immobilized. He also pointed out that healing regularly occurred in fractures of the femoral shaft, which in his time were treated only by extension without adequate fixation and where the fragments were necessarily moved at frequent intervals with the change of position of the patient in bed. Lucas-Championnière considered that a certain amount of motion was not inimical to callus formation and went so far as to state that from his experience a certain amount of motion in fractures seemed to accelerate the formation of callus Many surgeons now hold the view that complete immobilization is not necessary to fracture healing As a matter of fact, it is rarely if ever, complete as practically all splints permit at least a slight amount of motion at the site of fracture. To eliminate all motion it would be necessary to apply the splints so tightly that there would be danger of pressure necrosis In the modern functional treatment of fractures, early use of the injured part protected by splints, is strongly advocated. In the case of certain fractures of the lower extremity some surgeons employ weight-bearing splints at a period when the healing of the fracture is but little advanced on the grounds that functional recovery is hastened and bony union is

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The location of the fracture is of considerable importance in determining how complete immobilization should be. Fractures through the shafts of the long bones are much more likely to exhibit delayed healing or nonunion than fractures through cancellous bone, the variation here probably depending upon differences in vascularity Certain fractures are noted for delayed healing or failure to heal, as, for example, those of the scaphoid neck of the femur, both bones of the leg at the junction of the lower and middle thirds the shaft of the humerus in the middle third and both bones of the forearm in the middle and upper thirds. Here immobilization should be as complete as possible and should be maintained as long as necessary even at the expense of functional consideration On the other hand, fractures involving the other articulations or in the neighborhood of the articulations usually heal readily since they are situated in cancellous bone possessing ample blood supply Such fractures require meticulous reduction, but once reduced, early mobilization may be permitted with benefit.

Knowing the harm that may be done by prolonged immobilization, yet having to make use of it in loose fractures in order to maintain reduction, let us consider how some compromise may be reached in the interest of promoting functional recovery In general, fixation is accomplished by the use either of retentive apparatus or of traction splints The former category includes plaster of paris apparatus a variety of splints of different designs and materials and some simple dressings of bandage or adhesive plaster Under traction splints are included the various types of Thomas splints and special modifications of these intended for the arm shoulder leg and hip, and the so-called banjo splints for the fingers and toes

When applying retentive splints to a reduced fracture, the first rule should be to fix a time for their removal Especially is this necessary in the case of plaster-of-paris dressing This time may have to be prolonged if union proves not as far advanced as expected but nothing is worse than to prolong it without adequate reason When using circular plaster-of paris casings it is always a safe principle to split them on two sides as soon as they have hardened This guards against constriction and also makes possible the removal of the splints and examination of the fracture without unnecessary delay Secondly only those articulations should be immobilized whose movement would be inimical to maintenance of reduction or to fracture healing Thus in fractures of the forearm or wrist it is unnecessary to fix the fingers or thumb and active movement and use of the digits should be encouraged from the beginning The same is true of the toes in fractures of the lower leg and ankle. Total fixation of the ankle is frequently not required and a portion of the splint over the dorsum of the foot may be cut away to permit limited mobilization here without entirely sacrificing support of the foot. Movements of the shoulder or hip are not contraindicated in many fractures involving the extremities, but stiffening of these joints may occur during the period of fixation unless

adequate attention is directed toward preserving their function. Thirdly in so far as the requirements of the individual fracture permit, those joints that are to be immobilized should be fixed in the optimum position for functional recovery These are usually positions in which gravity will represent an aid instead of an obstacle to the recovery of motion Thus the shoulder recovers motion more readily when fixed in abduction the elbow in flexion the knee in extension and the ankle in right-angle flexion. Frequently the necessity of maintaining reduction of a fracture imposes a different position upon one of the articulations but the other joint may be fixed in accord with functional considerations Lastly it is frequently possible to remove the splints temporarily at regular intervals beginning immediately after the reduction to allow massage and mobilization The fixation thus becomes interrupted instead of continuous If the reduction is insecure with considerable danger of displacement the splint on one side may be removed and this surface exposed for treatment while the fracture is supported on the other side The splint may then be reapplied while the other one is removed to allow treatment Healing soon progresses to the stage when the part may be lifted out of the splints altogether and supported manually while mobilization is performed

Continuous traction or extension has been used for the fixation of certain fractures since ancient times. Although it overcomes shortening and secures reduction it does not of itself provide immobilization unless used in conjunction with fixative apparatus The traction splints devised by Thomas and popularized at the time of the Great War by Jones meet this need and provide both rigid external fixation and the opportunity for traction and countertraction It is essential to employ suspension in order to derive the greatest advantage from the use of traction splints Suspension means slinging the splint supporting the injured limb to an overhead frame by means of a system of cords weights and pulleys in such a way that the weight of the injured member is exactly counterpoised and its mobility greatly increased. Traction is maintained by a cord passing over a pulley at the end c the bed and fixed to a weight Traction-suspension is of great [illegible] a physical therapeutic measure and also in promoting the [illegible] comfort. With proper arrangement of the apparatus the [illegible] enabled to sit lie or change position to a limited extent [illegible] turbing the fracture This greatly facilitates the nursing [illegible] resulting activity is of benefit to the general musculature [illegible] tion. It permits the mobilization of joints that would [illegible] if retentive splints were used maintains muscular [illegible] swelling and generally hastens the recovery of [illegible] duction and general adoption of the traction-[illegible] certain types of fractures marks one of the [illegible] that has been made in treatment looking [illegible] function

The value of traction-suspension treatmen [illegible]

increased by the introduction of skeletal traction By this procedure traction is applied directly to the bone by the introduction of pins, tongs or the small flexible wire of Kirschner Skeletal traction as contrasted with the ordinary method of adhesive skin traction, has three great advantages First, the force is applied directly to the bone where its action is desired There is no loss from diffusion of the force as in the case of skin traction consequently the amount of force required is less Second, the point of contact of the skeletal appliance with the limb is small and as a result the entire region of the fracture and the distal part of the extremity are left uncovered The wide access to the limb thus gained is of considerable importance in permitting the use of massage and heat and also in the case of infected compound fractures in making possible examination and treatment of the wound. Third, when applied directly to the distal end of the fractured bone, it permits movement of the joints, not only above but also below the fracture, and thus creates almost ideal conditions for functional treatment

A third method of fixation that requires mention in any consideration of the ways of securing immobilization is that of internal fixation made possible by operation One of the advantages of open reduction is that it paves the way for securing such complete fixation of the fracture that early movement of the neighboring joints may be permitted and other measures instituted to counteract and overcome the effects of trauma to the soft parts In the case of relatively simple fractures where healing occurs rapidly, this may not constitute a sufficient advantage to justify prolonging the operation and introducing foreign material In that case the surgeon will rely upon external splints to maintain the alignment following operation, but he should make an effort to begin removing them temporarily at an early period to permit movement In the case of fractures that are likely to be displaced or that require a long period for healing half of the benefits of open reduction will be lost unless some method of strong internal splinting is used This usually means the introduction of metallic wire, screws bone plates or nails The great desideratum is that the fixation be made so secure by internal means that massage and movement can be started as soon as the patient has recovered from the operation. When this has been done little in the way of external support is required and protection is usually afforded either by retentive splints that may be removed for physical therapy or by traction-suspension apparatus which provides the opportunity for massage and movement.

Institution of Measures to Restore Function

There remains to be considered a third principle of fracture treatment that is of equal importance with the two that have been discussed previously namely the institution of measures to restore function. While atraumatic reduction of the deformity at the earliest

moment and maintenance of alignment afterwards by methods of splinting that minimize as far as possible the harmful effects of im mobilization are of aid in obtaining functional recovery their mode of action is more negative than positive in that they seek to lessen the ill effects of necessary treatment. Other measures capable of more directly influencing the pathologic changes in the soft parts must be adopted if the disability time of fractures is to be shortened and the functional results improved. The only measures at our command capa ble of accomplishing this purpose belong to the domain of physical therapy and they should be included just as regularly in the treatment of fractures and employed with the same skill as are reduction of the fracture and splinting to maintain alignment.

When we consider the pathologic changes arising from a fracture it is obvious that the immediate traumatic reaction and subsequent inflammatory process are of a reparative nature and have for their purpose the eventual formation of callus to heal the bone and of scar tissue to repair the injured soft structures. Much of the reaction in the soft tissues appears excessive however and out of proportion to the actual degree of damage The soft parts are flooded with exudate and involved in severe circulatory disturbances that are inimical to the preservation of their function The extension of hemorrhage between muscles and along fascial planes and into tendon sheaths leads through the organization of the blood clot to the formation of cicatri cial adhesions obliteration of gliding surfaces, and fixation of the mass of scar tissue to the callus with prevention of the shortening and lengthening reaction of the muscles The pouring out of exudate during the inflammatory reaction increases the swelling already present from hemorrhage and adds to the embarrassment of the circulation by mak ing pressure upon the veins and lymphatics and by blocking the latter with cellular products The unavoidable immobilization of the fracture intensifies and perpetuates this condition by abolishing all muscular contraction upon which the venous and the lymphatic circulation depend As organization advances to cicatrization the circulatory disturbances become fixed owing to the blocking of the drainage chan nels by the newly formed fibrous tissue Watson [14] expressed this con ception as follows Blood extravasated into the soft tissues serves no known useful purpose It is foreign material and in time is removed as such by the ordinary drainage media—the lymphatics and blood vessels If these effusions and extravasations are not rapidly removed organization will take place with the formation of adhesions between articular surfaces between tendons and their sheaths and between nerves and the surrounding tissues producing 'matting' of the soft parts " All of these changes find expression during the convalescent stage of treatment in swelling of the extremity impaired circulation joint stiffness and muscular weakness and are reflected in the patient s complaint of continued pain and inability to resume normal activities

As a matter of fact the time necessary to overcome venous stasis

increased by the introduction of skeletal traction. By this procedure traction is applied directly to the bone by the introduction of pins, tongs or the small flexible wire of Kirschner Skeletal traction, as contrasted with the ordinary method of adhesive skin traction, has three great advantages First the force is applied directly to the bone where its action is desired There is no loss from diffusion of the force as in the case of skin traction, consequently the amount of force required is less Second, the point of contact of the skeletal appliance with the limb is small and as a result the entire region of the fracture and the distal part of the extremity are left uncovered The wide access to the limb thus gained is of considerable importance in permitting the use of massage and heat and also in the case of infected compound fractures in making possible examination and treatment of the wound. Third when applied directly to the distal end of the fractured bone, it permits movement of the joints not only above but also below the fracture and thus creates almost ideal conditions for functional treatment

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was 206 5 days These figures assume even greater significance when it is pointed out that a very large percentage of these cases represented only fracture-sprains or fractures without deformity and very minor fractures such as those of the fingers or toes While it is doubtless true that other factors such as psychologic and economic considerations play a considerable part in determining the length of the convalescent period in industrial surgery it is nevertheless evident that the period of disability after fractures is longer than it should be and that the results of treatment are still far from satisfactory

Progress in improving the surgical part of the treatment of fractures is being made as the result of organized propaganda and educational work carried out among the members of the medical profession throughout the country While there still remains great room for further improvement along this line I do not believe that this will solve the problem. I look to the more general and intelligent use of physical therapy not by physical therapists but by physicians as the means of making the next great advance in fracture treatment. Physical therapy when rightly used that is beginning in the acute stage of injury is capable of influencing the pathologic changes of a fracture particularly those affecting the soft parts in a manner favorable to overcoming causes of delayed recovery This belief is shared by many experienced students of fractures Darrach [17] advised early massage both before and after reduction of the fracture and described the results as follows "The result is a decrease in pain and discomfort and improvement in circulation and so a hastening of repair It also prevents much of the stiffness in joints and muscles lessens the amount of atrophy and shortens the time for return of full power Watson,[14] reporting on his experience with 400 cases of fracture treated by early massage and mobilization stated Organization occurs during the first 9 to 10 days hence it is during this crucial period that the local drainage apparatus—the circulatory and lymphatic systems—already reduced in efficiency by the injuries received should be aided in their work of débris removal Massage rapidly removes these effusions and extravasations by restoring the local lymphatic and circulatory drainage to its former efficiency Murray [18] expressed himself thus It is today becoming recognized that physical therapy displays its chief and prime value in the early phase in that stage when hemorrhage exudate and transudate infiltrating the soft parts can be actually removed by painless physical therapeutic measures acting reflexly—not by direct pressure on the circulatory status of the part. Trethowan [19] said It is the acute case which benefits most from physical therapy and in which this expensive treatment is economically of most value When treatment is unduly delayed the efforts of the masseuse are devoted largely to combating the results of neglect—poor circulation disuse atrophy loss of power stiff joints contractures and adherent scars Galland [20] wrote as follows "The use of physical therapy must not be relegated to an attempt to rehabilitate cases

and edema, to restore normal circulatory conditions, to mobilize stiff joints, to free the scarred and contracted muscles and to build up their power is generally many times greater than the period required for the healing of the fracture Physicians who are engaged only in private or hospital practice frequently fail to realize this, as most of their patients are dismissed at the time when further active treatment ceases to be necessary and generally before function has been completely regained Industrial surgery has furnished a very useful check on the duration of disability as under the industrial compensation laws the patients have to be followed and treated, not only until their fractures have healed, but until they are able to return to work Since most of the patients are employed at jobs necessitating heavy labor it is impossible for them to resume their occupations before they have obtained nearly complete functional recovery

Studies of fractures among this group have shown that the disabling effects of the injury continued for a long period after the fracture itself had healed The disability time of a fracture may be divided into two periods the first, the period of consolidation, which extends from the moment of injury to the time when healing is sufficiently firm to permit the removal of fixative apparatus and the beginning of active use either with or without protection and the second, the period of convalescence which extends from the end of the consolidation period to the time when functional restoration is sufficiently complete to allow the resumption of normal activities or work. Figures obtained from the Industrial Accident Commission of Massachusetts [15] showed that the average duration of temporary total disability after fracture of the wrist was 9 weeks whereas the period of consolidation was usually 3 to 4 weeks and after fractures of the region of the shoulder it was 16 7 weeks against a consolidation period of 4 to 5 weeks. These figures were for all cases and included a large number of fractures of very minor nature, and in addition did not include the period of partial disability which in industrial cases is often very long End result studies at the Massachusetts General Hospital showed that fractures of the bones of the lower leg rarely recovered before the end of 6 to 8 months against a consolidation time of 10 to 12 weeks and that fractures of the shaft of the femur usually caused disability of 10 to 12 months, whereas consolidation was usually complete in 8 to 10 weeks. The length of the convalescent period in relation to that of the consolidation period affords a rough measure of the effectiveness of functional treatment of a fracture One would expect that a ratio of 2 1 that is a convalescent period twice as long as the period of consolidation would be a generous allowance in most cases, but actually under average treatment at present the ratio runs frequently 4 1 5 1 and even higher In the report of the Research Group of the Committee on Traumatic Surgery of the American College of Surgeons,[16] it was stated that out of a group of 863 fractures studied only 62 5 per cent made complete recovery The average duration of disability

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functionally impaired after long-continued surgical treatment of fractures but must be included in our scheme of treatment from the earliest phase of handling the condition " The pioneer of physical therapy in fractures, Lucas-Championnière,[1] always emphasized that massage and mobilization should be used from the very beginning if the most striking results were to be obtained His English disciple, Mennell [3] has been equally convinced of this and described the effects as relief of pain and spasm, improvement in nutrition and earlier functional restoration

Physical therapy must therefore be employed within the first two weeks of injury if any effect is to be obtained in the removal of hemorrhage and exudate. During the remainder of the period of consolidation the chief function of physical therapy is in preserving the suppleness of the muscles, preventing adhesions maintaining joint mobility improving the circulation and in general, counteracting the effects of immobilization While physical therapy can be of great assistance in the early stage of fracture treatment, it must be pointed out that this is precisely the period when there is the greatest danger of displacing the bone fragments and when the greatest harm is likely to result from undue motion at the seat of fracture Treatment at this time cannot be entrusted to a technician with any safety, and if physical therapy is to be employed it will have to be administered either by the physician in person or directly under his supervision. Above all the treatment must have the quality of painlessness and if it cannot be administered without pain it had better be abandoned. When the period of convalescence has been reached and active use can be permitted chief reliance must be placed in the patient's own efforts and the rôle of physical therapy becomes chiefly educational, in showing the patient how to help himself by muscle reëducation and exercise. Physical therapy is valueless when long continued after the healing of the fracture and there is little doubt that in this respect it has been subject to much abuse in the past. The Research Group of the Committee on Traumatic Surgery of the American College of Surgeons [14] reported that a careful review of our statistical data justifies the opinion that the application of physiotherapy as now practiced generally does not warrant our approval nor does it indicate that sufficient benefits are derived to justify its application indiscriminately and when used it should be used early for a limited time

Of the various agencies or modalities that are employed under the general designation of physical therapy such as thermal stimulation, massage movement, irradiation and electrical stimulation only the first three are of established value in the treatment of fractures. In addition the importance of elevation or postural treatment as an aid to physical therapy should be mentioned. Thermal stimulation includes heat and cold. The latter is used infrequently but may be employed occasionally to check swelling under special conditions Heat has the same action whether obtained by hot compresses heating pads, radiant

lamps diathermy or hot baths It is soothing and relieves pain It also brings about a vascular flushing of the part that may be of benefit as a preliminary to massage and movement. The use of heat is some times indicated in the early stage of fracture treatment to stimulate the circulation of an extremity when it is gravely embarrassed as the result of extensive injury and swelling

Massage of the light stroking variety described by Lucas-Championnière, is of great value in the early acute stage of a fracture and probably produces its effects reflexly through the nerves It relieves pain and muscle spasm and has a direct effect in stimulating the circulation and overcoming vasomotor paralysis In the later stage of fracture treatment deep stroking massage and kneading provided that they are painless are useful for their mechanical action in getting rid of edema and improving nutrition. Movement is the complement of massage and massage is almost a waste of time in the treatment of fractures unless supplemented by motion In the early stage the movement should be of the passive type with the patient s muscles completely relaxed. Any active muscle contraction would cause movement at the seat of fracture and result in spasm and pain. Passive movement stimulates the circulation prevents adhesions and contraction of the muscles and maintains joint flexibility In proportion as consolidation of the fracture proceeds the character of the movement is changed from passive to active motion through the gradation of assisted movement. After union has become firm, chief reliance must be placed in active use and exercises performed by the patient. At this time occupational therapy offers a means of breaking the monotony of exercises by adding the interest and stimulus of performing a useful task.

Ultraviolet irradiation is not known to have any specific effect on fractures beyond its general action of stimulating calcium metabolism in the body In conditions of disturbed calcium metabolism this action may be desirable, but its use should be reserved for this Electricity in its various forms seems only to offer other means of obtaining the same effects as can be brought about by the use of heat massage and movement. Diathermy has not been shown to have any specific action other than that of supplying heat centrally in the tissues It is subject to great errors unless managed by a highly skilled person A stimulating effect upon delayed consolidation has been claimed for it but has not yet been proved The static brush provides the equivalent of light stroking massage The various forms of electrical stimulation of muscle contraction by galvanic faradic and sinusoidal currents undoubtedly may be of service under certain indications but must be managed with great skill and at best their use is likely to be dangerous In addition the machines are costly not easily transportable to the patient s bed side and not infrequently produce unpleasant psychologic reactions objections which seriously limit their use in the treatment of fractures The Morton Smart [21] machine which produces a completely controlled high frequency current of a surging type seems to be one of the best

for obtaining graduated muscle contraction and relaxation, but its place in fracture treatment at present is *sub judice*

Physical therapy has always been subject to criticism because of the small body of scientific knowledge underlying the use of its various agencies, and because of its claims of therapeutic actions for which there existed no real proof Unfortunately much of this criticism is justified Mechanical development has temporarily outrun experimental study with the result that a lot of different electrical machines have been produced for which every beneficial therapeutic effect is claimed that can be supported by enthusiasm or high-powered salesmanship. It is therefore important to differentiate between the agencies that are based on long clinical experience and observation and those that are not. Massage and mobilization, while lacking the complete scientific explanation of their mode of action that at present is desirable have behind them a mass of clinical experiences which began in antiquity and which collectively constitutes valid evidence of their effectiveness. It is the same kind of evidence as that which led to the discovery and recognition of the therapeutic value of mercury and potassium iodide in syphilis, of quinine in malaria, or iron in anemia and of cod liver oil in rickets many years before scientific data had been adduced to prove their value. The actions of the various agencies of physical therapy are susceptible of experimental investigation, and it is to be hoped that investigators will be stimulated to cultivate this rich but untilled soil. Until the results of such investigations are forthcoming, we will do well to confine our use of physical therapy, especially in the treatment of fractures to those agencies which have stood the test of prolonged clinical experience.

The age of the patient has considerable bearing upon the need for physical therapy In children not only does consolidation of the fracture occur more rapidly but the effects of the traumatic reaction upon the soft parts are also more quickly overcome The natural activity of children and their love of play quickly restores function and it is more often necessary to hold them back than to push them forward. Consequently physical therapy is unnecessary and usually but a waste of time in children below the age of fifteen years. Beyond this age the reactions to trauma are of the adult type and physical therapy should be employed. Conditions for overcoming the effects of injury and restoring function become less favorable with increasing years until in old age they become definitely adverse The less favorable the age of the tissues the greater is the need for early physical therapy The most fertile field for physical therapy in fractures is found in the middle-age period Not only is this the period when bony injuries are common owing to the greater exposure to trauma but it is also the period of active wage earning when the individual can least afford unnecessary loss of time. Functional disability must be shortened and permanent crippling avoided by the use of every therapeutic resource.

The type of fracture and its location are the most important factors

in determining whether or not physical therapy can be employed in the early stage In the case of a loose displaced fracture, all depends upon the security of the reduction Rather than to incur the risk of secondary displacement it is better to postpone the use of physical therapy until consolidation is well advanced Fractures of the shafts of long bones are particularly dangerous in this respect, and early massage and mobilization can be employed only in a limited way, chiefly after open reduction and internal fixation or in conjunction with skeletal traction and suspension On the other hand in the case of fractures of cancellous bone conditions are much more favorable for the early use of massage and mobilization since there is much less risk of displacement and union tends to occur rapidly on account of the abundant blood supply Thus the most spectacular results are achieved in fractures of the lower end of the radius and the upper end of the humerus In fractures of the lower end of the humerus, a good deal depends upon the individual type of fracture and its stability after reduction some can be treated early and others cannot Early physical therapy can be employed with great advantage in certain fractures of the knee and ankle but subject to the limitations imposed by the individual case and the danger of losing the alignment. In fractures of the hip and wrist especially of the carpal scaphoid physical therapy is absolutely contraindicated except in the late stage because of the danger of nonunion

Undisplaced Fractures

Fractures without displacement constitute a large and important group of injuries whose number is constantly growing larger as the practice spreads of making roentgenologic examinations in all cases of injury irrespective of whether fracture is suspected or not. They include incomplete and fissured fractures subperiosteal fractures green stick fractures impacted fractures and many of the comminuted fractures in cancellous bone Strictly speaking they are not altogether fractures without displacement as deformity of greater or lesser degree may be present in certain impacted or greenstick fractures but they represent cases in which the deformity is either not of a disabling character or in which because of the nature of the fracture or the condition of the patient there is more advantage in leaving the deformity than in attempting to correct it. The latter applies particularly to the comminuted fractures of the upper end of the humerus and to the impacted fractures of the neck of the femur in aged individuals In the first correction of the deformity necessitates fixation of the shoulder and results in stiffness some of which may prove permanent while on the other hand immediate treatment by massage and movement yields such good results even in the presence of considerable deformity that the latter plan may have the preference In the case of impacted fractures of the hip—which are of rarer occurrence than

generally believed—correction of the deformity means breaking up the impaction and incurring the risk of nonunion, in addition to the disadvantages of prolonged treatment in a plaster spica In comparison with this, the treatment of the impacted fracture is so much simpler and safer that the deformity must be great indeed to justify taking the risks of the alternative course Lucas-Championnière [32] used to say that impaction represented the first stage of fracture repair already completed, and even went so far as to advise against disturbing it in Colles fracture except in extreme instances. While I cannot subscribe to this extreme view I do feel that there is every advantage in preserving impaction when there is no great deformity

The treatment of undisplaced fractures affords a relatively simple problem both because of the lack of necessity of reduction and the ease of maintaining alignment. When a fracture has withstood the primary trauma without displacement, there is little danger of secondary displacement and all that is required in the way of fixation is light protective splinting of an easily removable type or traction-suspension to counteract the weight of the extremity This group of fractures offers an ideal opportunity for treatment from the beginning by physical therapy Superficial stroking massage and passive and assisted motion may be begun at once without the slightest danger Rational use of these measures combined with rest and elevation will restore the circulation, maintain the suppleness of the muscles and the flexibility of the joints and promote early recovery It cannot be emphasized too strongly that complete and prolonged immobilization of such fractures represents a surgical crime

Summary of Fracture Treatment

Rapid functional recovery from a fracture depends not upon emphasizing any one particular method of treatment, but upon attempting to apply in the proportions adapted to the needs of the individual case the three cardinal principles of fracture treatment early reduction, maintenance of alignment and institution of therapeutic measures to promote the return of power and function. While wide latitude is permitted in the details of treatment, and different surgeons may adopt widely different methods to attain the same end the principles underlying the treatment should remain the same The goal of functional recovery should be constantly visualized, and the obstacles to be overcome in achieving this objective should be foreseen in each case and the treatment planned accordingly Physical therapy represents only one means of attaining this goal, of value when it can be carried out in an ideal way of secondary importance when other considerations are more imperious The inability to employ physical therapy may be counterbalanced by attention to other details of treatment and particularly by the use of every method that tends to

promote early activity and to shorten and render less continuous the period of immobilization.

The following represents a recapitulation of the more important points of treatment that have been mentioned in the preceding sections

1 Splint all fractures at the place of the accident in order to prevent the additional pain displacement and soft part injury that will otherwise result during the transportation of the patient to the hospital or home

2 Seek to obtain complete reduction of the fracture at the earliest possible moment after the injury by the use of that method whether of the closed or open type which offers the greatest chance of success with the avoidance of unnecessary and additional trauma by repeated efforts at reduction

3 Try to splint the part in such a way that the greatest amount of use will be permitted without jeopardizing the position of the fragments.

4 Immobilize as few articulations as necessary to preserve the alignment and to provide favorable conditions for healing.

5 In so far as the requirements of the individual fracture permit immobilize the joints in the positions most favorable for the rapid recovery of function Thus the wrist should be fixed when possible in a position of dorsiflexion the elbow in a position of flexion and the ankle joint in a position of right angle flexion In these positions the action of gravity favors the return of motion and any stiffness that may result will be less likely to cause disability

6 Urge active motion and use of the adjacent and unimmobilized joints from the very beginning. Thus in the case of injuries of the upper extremities the fingers and hand should be left free whenever possible and their use encouraged When the shoulder joint is not fixed regular exercises should be instituted to prevent contractures and loss of strength In the case of the lower extremity likewise movement should be encouraged of all the unimmobilized joints even if only of the toes. It should be remembered that the muscles activating these structures span considerable distances and often arise in the region of injury Their contraction and use will be of great aid in getting rid of edema and exudate and in maintaining normal nutrition.

7 Avoid the dependent position and employ elevation of the part whenever necessary in order to reduce swelling and provide local conditions as favorable as possible for normal circulation

8 When it is necessary to apply rigid plaster-of-paris casts begin immediately to make plans for their removal at as early a period as possible to permit massage and mobilization It will often be found possible to [illegible]

generally believed—correction of the deformity means breaking up the impaction and incurring the risk of nonunion in addition to the disadvantages of prolonged treatment in a plaster spica. In comparison with this the treatment of the impacted fracture is so much simpler and safer that the deformity must be great indeed to justify taking the risks of the alternative course Lucas-Championnière [18] used to say that impaction represented the first stage of fracture repair already completed and even went so far as to advise against disturbing it in Colles fracture except in extreme instances. While I cannot subscribe to this extreme view I do feel that there is every advantage in preserving impaction when there is no great deformity

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Technic of Physical Therapy in Fractures

Massage.—Of the various types of massage that have been described by different teachers and writers there are only three that are of value in the treatment of fractures These are superficial stroking effleurage and kneading. The other forms of massage such as friction pétrissage and the different percussion movements or tapotement are far too vigorous to be tolerated in a recent fracture and even in the convalescent stage accomplish nothing but harm. Indeed it has always been a criticism of massage as performed by the average technician in the treatment of injury that it is too strenuous and does harm rather than good All too frequently it has been the aim to give the patient all he could stand an objective inspired in part by the desire of the patient to be sure and get his money s worth and in part by the lack of specific instructions as to what was wanted from the doctor Vigorous massage of an injured part is given under a complete misapprehension of the goal that is sought, namely to secure muscular relaxation and to benefit the circulation Pain is always to be regarded as the warning signal and massage that is painful is also harmful.

Early Massage of a Recent Fracture.—Massage of the peculiar superficial stroking type advocated by Lucas-Championnière [1] and his pupils is employed for the treatment of fresh fractures to relieve pain secure muscular relaxation overcome swelling and to benefit the circulation As has been said before it precedes and paves the way for mobilization Its application is necessarily limited by the location and type of the fracture. To produce its full effects the entire surface of the limb should be exposed to treatment. When dealing with loose displaced fractures this cannot be done without jeopardizing the reduced position of the fragment. Such fractures if they are to be treated at all must be treated over the small area that can be exposed by local adjustment of the splint. In some instances when the injured part is fixed by anteroposterior or lateral splints one splint may be removed and the part supported on the other splint while the exposed surface is treated This splint is then replaced the position reversed and the other splint removed for treatment. The types of bony injury ideally suited for early massage and mobilization are the incomplete impacted or undisplaced fractures Because of the little tendency to displacement of such fractures it is possible to remove the splints with safety and to support the part by cushions in a manner to permit complete treatment In any case regardless of the type of fracture it is important that the part shall be completely supported in order to obtain the utmost of muscular relaxation before proceeding with the massage Generally it is more difficult for a patient with a sensitive extremity to relax when sitting than when lying and for this reason the recumbent position is usually to be preferred The position of the joints should be semiflexed by the adjustment of pillows or cushions to insure the utmost comfort and relaxation.

of the plaster, as, for example, over the dorsum of the foot to permit a little movement of the ankle When molded plaster or other splints are used, as in fractures of the lower end of the radius, or in the region of the elbow, make a point of removing the splints temporarily for massage and mobilization treatment, beginning a few days after injury

9 When a fracture is treated by continuous traction, the extremity should be suspended and counterpoised in order to permit as much movement as possible of the proximal articulation while at the same time increasing the efficiency of the apparatus and promoting the patient's comfort When skeletal traction is used, advantage should be taken of it to mobilize regularly, when possible the joint distal to the point of insertion of the pin wire or tongs Thus for example, in the case of a fracture of the shaft of the femur with traction by Kirschner's wire through the femoral condyles it is often possible to begin partial mobilization of the knee joint within two weeks of the time of injury In the cases of fractures of the upper end of the humerus that are treated in traction-suspension, it is often possible to suspend the forearm separately and to permit a little movement of the elbow and of the shoulder

10 When the convalescent stage of treatment is reached substitute light protective splints for completely immobilizing splints whenever possible, thus permitting a greater range of functional activities In the case of the lower extremity, weight bearing appliances such as Thomas calliper braces or close-fitting plaster casings fitted with steel walking stirrups should be used whenever possible to counteract atrophy and stimulate the circulation

11 Physical therapy consisting mainly of light stroking massage and gentle passive motion should be administered when possible without jeopardizing the position of the fragments, in the first two weeks of injury to favor absorption of exudate and to improve the circulation. It should be continued regularly through the period of consolidation changing gradually its character in proportion to the advance of callus formation. In the convalescent stage active motion and use are of chief value, and the main function of physical therapy should be educational.

12 Fractures without displacement are subject to little risk of secondary displacement and require only light protective splinting of an easily removable type or traction and suspension. Massage and mobilization should be employed in practically all such fractures from the very beginning Continuous and prolonged immobilization of such fractures causes as much disability as the injury itself and should be avoided at all costs.

MASSAGE IN THE LATER TREATMENT OF FRACTURE.—Massage should never be more than of the light stroking type during the active phase of fracture treatment. Only when union is solid enough to permit the temporary or complete removal of the splint should any deeper pressure be permitted Then deep stroking massage or effleurage supplemented occasionally by kneading may be employed for their mechanical effect in helping to drain the clogged lymphatics and to empty surplus fluid from the tissue spaces Since its action is mechanical instead of reflex effleurage should be administered only in the centripetal direction and always in the manner advocated by Wharton Hood [22] of beginning by massaging the tissues of the proximal portion of the extremity and emptying these, then proceeding a little distally and working back again over the proximal region and repeating this maneuver as many times as necessary until the entire extremity has been treated This procedure is based on the principle that the proximal lymphatic and venous circulation must be stimulated and the channels cleared before the fluid can be removed from the distal part with success

While effleurage is classed as deep stroking massage and requires deep pressure this does not mean hard or forcible pressure The main requirement in order to administer effleurage properly is muscular relaxation As long as the muscles are hard and contracted even the most vigorous pressure would scarcely be able to produce any deep effect On the other hand with muscular relaxation the tissues transmit gentle even pressure to the depths just as if they were a fluid medium. Light superficial stroking should always be employed to relax the muscles before proceeding with deep stroking and even after this has been begun when certain regions are found to be hard instead of soft then one should return to the superficial stroking until these muscles have relaxed. Effleurage is intended to aid in the restoration of vasomotor tone and to assist in moving venous blood and lymph thereby improving the nutrition of the tissues and promoting the elimination of waste products

Massage of a kneading type may be used sometimes to supplement deep stroking movements when nontender fibrotic thickenings are encountered that do not respond to the latter It is more often needed when dealing with an indurated scar in the muscles resulting from extensive soft tissue damage It ought to be used only when complete union has been obtained and never when its administration is attended by the slightest pain There seems to be no place in fracture treatment for the use of the deeper movements of massage such as friction pétrissage or any of the percussion movements such as tapotement hacking clapping, beating vibrating or shaking The value of these movements is debatable under almost any conditions, and they certainly have no place in the therapy of injuries.

Mobilization.—Nothing is so important as movement for restoring function after a fracture It represents the very essence of function

Superficial stroking is the only type of massage that should be employed in the early treatment of fractures Its practice can only be perfected by actual experience The movements must be slow, gentle and rhythmical, and made with the flat of the fingers, the hand being relaxed so as to adapt and mold itself to the part. The stroke should cover as large a part of the limb as possible, but should avoid the region immediately overlying the fracture until this ceases to be painful In the case of the upper extremity the stroke should include the whole area from the hand to the shoulder, and in other regions it should be equally extensive The contact with the skin should be so gentle that the patient scarcely feels the touch Lucas-Championnière likened it to "little more than a caress " It should be performed in one direction only, and as it is employed chiefly for its reflex action, it matters little whether the direction is centrifugal or centripetal. The rhythm should be slow and even, and the same when the hand is returning through the air as when in contact with the skin As lubricants I usually employ alcohol and talcum powder but if the effect of these upon the skin becomes too drying it may be necessary to substitute olive oil.

The whole purpose of massage treatment in a recent fracture is to produce reflex effect, and the benefits that are obtained can scarcely be explained upon any other basis The stroke is too light and gentle to have any mechanical action upon the edema and swelling Furthermore when the extent and degree of the swelling in a recent fracture are considered it is evident that vascular dilatation or relaxation plays a large rôle in its causation. Vascular tone is maintained normally by the vasomotor nerves and it is not unreasonable to suppose that in a state of vasomotor paralysis this nervous mechanism may be influenced by surface stimulation Lucas-Championnière attributed the relief of pain in part to exhaustion of the sensory nerve ending by the repeated surface stroking and this is as good an explanation of this part of its action as any that have been suggested The benefits of the massage when properly performed manifest themselves by relief of pain and relaxation of muscle spasm After relaxation has been obtained then gentle movements of the passive type may be made. Even a small amount of motion in the beginning is beneficial and later this can gradually be increased. It is always a matter for astonishment to witness the soothing effect of massage in a recently injured extremity to see the muscles relax and movement be permitted that formerly was completely prohibited.

In the early stage of fracture treatment it is important not to tire the patient by too long treatment. The séances should be short, not exceeding fifteen to twenty minutes and the treatments should be given daily or on alternate days They should always begin and end with superficial stroking mobilization of the joints being given between the two periods of massage

Massage in the Later Treatment of Fracture.—Massage should never be more than of the light stroking type during the active phase of fracture treatment Only when union is solid enough to permit the temporary or complete removal of the splint should any deeper pressure be permitted Then deep stroking massage or effleurage supplemented occasionally by kneading may be employed for their mechanical effect in helping to drain the clogged lymphatics and to empty surplus fluid from the tissue spaces Since its action is mechanical instead of reflex, effleurage should be administered only in the centripetal direction and always in the manner advocated by Wharton Hood [22] of beginning by massaging the tissues of the proximal portion of the extremity and emptying these then proceeding a little distally and working back again over the proximal region and repeating this maneuver as many times as necessary until the entire extremity has been treated. This procedure is based on the principle that the proximal lymphatic and venous circulation must be stimulated and the channels cleared before the fluid can be removed from the distal part with success

While effleurage is classed as deep stroking massage and requires deep pressure, this does not mean hard or forcible pressure The main requirement in order to administer effleurage properly is muscular relaxation. As long as the muscles are hard and contracted even the most vigorous pressure would scarcely be able to produce any deep effect. On the other hand with muscular relaxation the tissues transmit gentle even pressure to the depths just as if they were a fluid medium. Light superficial stroking should always be employed to relax the muscles before proceeding with deep stroking and even after this has been begun when certain regions are found to be hard instead of soft, then one should return to the superficial stroking until these muscles have relaxed Effleurage is intended to aid in the restoration of vasomotor tone and to assist in moving venous blood and lymph thereby improving the nutrition of the tissues and promoting the elimination of waste products

Massage of a kneading type may be used sometimes to supplement deep stroking movements when nontender fibrotic thickenings are encountered that do not respond to the latter It is more often needed when dealing with an indurated scar in the muscles resulting from extensive soft tissue damage It ought to be used only when complete union has been obtained, and never when its administration is attended by the slightest pain. There seems to be no place in fracture treatment for the use of the deeper movements of massage such as friction pétrissage or any of the percussion movements such as tapotement hacking clapping beating vibrating or shaking The value of these movements is debatable under almost any conditions, and they certainly have no place in the therapy of injuries.

Mobilization.—Nothing is so important as movement for restoring function after a fracture It represents the very essence of function

Superficial stroking is the only type of massage that should be employed in the early treatment of fractures Its practice can only be perfected by actual experience The movements must be slow, gentle and rhythmical, and made with the flat of the fingers the hand being relaxed so as to adapt and mold itself to the part The stroke should cover as large a part of the limb as possible, but should avoid the region immediately overlying the fracture until this ceases to be painful In the case of the upper extremity the stroke should include the whole area from the hand to the shoulder, and in other regions it should be equally extensive. The contact with the skin should be so gentle that the patient scarcely feels the touch Lucas-Championnière likened it to "little more than a caress" It should be performed in one direction only, and as it is employed chiefly for its reflex action it matters little whether the direction is centrifugal or centripetal. The rhythm should be slow and even, and the same when the hand is returning through the air as when in contact with the skin As lubricants I usually employ alcohol and talcum powder, but if the effect of these upon the skin becomes too drying it may be necessary to substitute olive oil.

The whole purpose of massage treatment in a recent fracture is to produce reflex effect, and the benefits that are obtained can scarcely be explained upon any other basis The stroke is too light and gentle to have any mechanical action upon the edema and swelling Furthermore when the extent and degree of the swelling in a recent fracture are considered it is evident that vascular dilatation or relaxation plays a large rôle in its causation Vascular tone is maintained normally by the vasomotor nerves and it is not unreasonable to suppose that in a state of vasomotor paralysis this nervous mechanism may be influenced by surface stimulation Lucas-Championnière attributed the relief of pain in part to exhaustion of the sensory nerve ending by the repeated surface stroking and this is as good an explanation of this part of its action as any that have been suggested The benefits of the massage when properly performed, manifest themselves by relief of pain and relaxation of muscle spasm After relaxation has been obtained then gentle movements of the passive type may be made. Even a small amount of motion in the beginning is beneficial, and later this can gradually be increased It is always a matter for astonishment to witness the soothing effect of massage in a recently injured extremity to see the muscles relax and movement be permitted that formerly was completely prohibited

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fracture instead of at the articulation that it serves as an excuse for physicians to manipulate joints violently in pump-handle fashion of which the harmful results have been frequently seen and that the goal that is aimed at by passive motion can be obtained with much greater benefit to the patient from the use of active motion. Such criticisms are made without knowledge of what passive movement is or of what it is intended to accomplish. I do not dispute the greater value of active movements when they can be performed but I know that passive motion can be employed in patients with fractures when active motion would only be harmful Passive motion is not advocated as a substitute for active movement, but only with the aim of getting movement started as early as possible and of employing it to lead up to active movement just as massage leads up to passive motion. The criticism that passive motion is resisted by the patient s muscles is made without proper understanding of the fact that passive motion is employed only with the patient s muscles completely relaxed. Passive motion that is resisted by the patient is no longer passive motion, but resisted movement and the physiotherapist who cannot distinguish between these two types of movement is not worthy of the name Mr Mennell of London[3] has suggested that the name *relaxed motion* be substituted for the term *passive motion* in order to promote better understanding of what it really is and this change appears advantageous Passive motion is undoubtedly subject to abuse just as are most procedures of medicine and surgery but the remedy is proper instruction rather than complete abandonment of the method

Relaxed Motion.—Relaxed motion is employed in the treatment of fractures as the first effort at mobilization In certain types of fractures that are attended by little danger of displacement of the fragments it may be employed in conjunction with light stroking massage beginning immediately after injury In other cases where the risk of displacement is greater its use must be postponed until consolidation is sufficiently advanced to obviate this risk It may be used frequently at an early period in conjunction with the traction-suspension treatment of fractures As has been explained previously it requires complete muscular relaxation on the part of the patient and this is best induced by a preliminary treatment of light stroking massage lasting from ten to fifteen minutes Relaxation can only be obtained when all of the preliminary treatment leading up to mobilization including the removal of the splint the handling of the limb and the massage has been characterized by extreme gentleness Never even for a moment should there be the slightest interruption of the physical therapist s constant vigilance to avoid pain The slightest sensation of pain will cause the patient s muscles to tighten and defeat the purpose of the treatment

The treatment should be given with the patient sitting or recumbent and with the part arranged in a position which permits relaxation and allows the physiotherapist to reach it in the most convenient

and to gain motion is the goal of all forms of physical therapy Mobilization is the *raison d'être* of massage in the treatment of injuries of bone, and massage without movement is almost a waste of time. "Movement is life" was the maxim of Aristotle quoted by Lucas-Championnière, and in the case of an injured extremity there is no doubt that movement is the means of restoring life. It stimulates the circulation aids in the absorption of edema and other products of inflammation restores the flexibility of the joints, frees the muscles from adhesions overcomes atrophy and restores strength. Determination and persistence on the part of the patient in moving the joints that have been immobilized will restore function after the majority of fractures, even in the absence of medical supervision This, however, is the harder and longer way and few individuals possess the necessary fortitude or can afford the loss of time necessitated by the slower method of progress. In order to obtain the best results, movement should be employed scientifically from the very beginning and with due regard for the pathologic physiology of the injured structures, and when used in this way it affords the means of shortening the period of convalescence and of improving the functional result

A great deal could be written on the subject of movement, but this has been considered in detail elsewhere in this work and our purpose is merely to review the different forms of movement in relation to the treatment of fractures. Movement may be divided into two classes—active and passive Under passive motion are to be considered relaxed motion and forced motion Under active motion are included the subdivisions muscle setting free motion assisted motion and resistive exercises

Passive Motion —Before considering the use of passive motion it will first be necessary to define what is meant by this term Passive movement is motion that is performed without either active help or resistance from the patient's muscles It requires mental coöperation on the part of the patient in securing complete muscular relaxation. To obtain this coöperation in the case of a patient with a fractured extremity is an art that requires the maximum of patience and gentleness on the part of the physical therapist. It is here that gentle strok ing massage has an important rôle in preparing the way and obtaining relaxation. Extreme gentleness is the *sine qua non* of success The slightest jar or sudden movement will cause the patient's muscles to tighten and harmful resistive motion will be substituted for beneficial passive movement.

It is this feature that accounts for the ill repute that has at times attached to passive motion There are a number of surgeons who can see nothing but danger in the use of passive motion and who would abandon it altogether for active, voluntary motion. They claim that even at its best, it is likely to provoke resistance from the patient's muscles and cause movement to take place at the seat of

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manner and to work at the utmost mechanical advantage The patient must at all times have a feeling of complete security The amount of motion to be administered is to be determined only by actual experiment. "Little but often" is the best principle In the beginning the amplitude of the movement is less important than the fact that some movement is made Even a little motion helps the circulation, promotes the absorption of exudate and keeps the joints supple. As the treatment proceeds, the range of movement can gradually be increased. The physical therapist s finger tips must be sensitive to detect the slightest sign of muscular resistance, and this is to be interpreted as the sign that the range of motion is exceeding the therapeutic limit. Preferably the motion should be performed with the joint semiflexed and with the neighboring joints in the positions that favor the freest motion as, for example, dorsiflexion of the wrist for flexion and extension of the fingers flexion of the elbow for supination of the forearm, flexion of the knee for dorsiflexion of the ankle, etc. Until healing is well advanced, the arc of relaxed movement should never exceed 50 to 60 per cent of the normal range of joint motion

The whole purpose of relaxed motion is to get movement started when it cannot be performed in any other way As consolidation of the fracture progresses relaxed motion should shade off into one of the forms of assisted movement, and finally through this gradation to active exercise performed entirely by the patient. As soon as movement that could at first only be performed passively can be done by active contraction of the patient s own muscles no further reason exists for the use of passive motion, and this should be stopped

The movement should be made with the physical therapist supporting the region of the fracture with one hand while supporting the weight of the limb with the other All of the joints of the injured extremity should be moved in every direction of which they are capable. In addition the mobilization should extend to certain movements which are not a part of the regular joint motions although necessary to good function, such as lateral mobilization of the patella on the trochlea, which frees and relaxes the lateral expansions of the capsule and quadriceps muscle and mobilization of the heads of the metatarsals or metacarpals both individually and in relation to each other which maintains and restores the normal flexibility of the plantar and palmar arches.

Forced Motion—The only purpose of mentioning the forcible variety of passive motion is to warn against its use for the treatment of fractures To be of the truly passive type forced motion must be performed with the patient completely anesthetized in order to obtain muscular relaxation This is a dangerous procedure as the pain reflex is abolished and the operator lacks that warning signal to indicate when structures are being injured. If forcible motion is made with the patient awake it is resisted by his muscles and quickly degenerates into a strength test between patient and doctor from which the latter

is likely to emerge the victor at the cost of considerable damage to the patient Manipulators and bone setters have developed a certain skill in performing sudden forcible movements when the patient's muscles are off guard but such manipulations are but rarely indicated after fractures and expose the patient to more risk than gain.

The only purpose of forced movements is to break up adhesions between muscles or to stretch a contracted joint capsule and such conditions are best overcome by active and assisted exercises The use of forcible manipulation after fractures is very likely to result in refracture or failing this may lead to the rupture of soft tissues with hemorrhage and the later development of an ossifying hematoma or ossifying myositis, examples of which have been seen all too frequently in the regions of the elbow Under the best of circumstances forced movements cause tissue damage with resulting pathologic changes that delay recovery and prevent the gain of motion thus defeating the very end that is being sought.

Active Mobilization.—Active motion may be subdivided into four classes or groups muscle setting free motion, assisted motion resisted motion.

Muscle Setting —Muscle setting is a muscle exercise rather than a motion as it is not intended that it should be accompanied by any joint movement. It consists in teaching the patient actively to contract or tense certain muscles or muscle groups without producing movement. This produces an effect in maintaining the circulation and nervous control of the muscles and of counteracting atrophy This exercise is of great value in the treatment of fractures and since there is no accompanying movement it may be performed from a very early period after injury and even when the part is completely immobilized by splints As the exercise takes very little time and is not attended by pain it may be performed from 75 to 100 times a day divided in two or three sessions

Muscle setting is of the greatest value in maintaining the tone and suppleness of the quadriceps extensor muscles of the thigh in the case of fractures involving the lower extremity This muscle group deteriorates rapidly with immobilization and as it plays a vital rôle in controlling and stabilizing the knee joint maintenance of its function is of great importance. When quadriceps-muscle setting has been employed systematically after a fracture of the lower extremity the muscle recovers its strength and extensibility more quickly and the function of the knee joint is also better Muscle-setting exercises may likewise be employed in the case of the deltoid muscle, the flexor muscles of the elbow and the extensors of the foot. If the leg is incased in plaster, the action of the extensor muscles can be much augmented by cutting out the portion of the splint covering the dorsum of the foot and ankle so as to permit a little ankle movement Some individuals are much quicker than others in learning the trick of muscle setting and much

patience and persistence may be required before satisfactory performance of the exercise is obtained The patient should be taught by first using the muscles of the uninjured side for demonstration purposes, and only when satisfactory control has been acquired here should he be permitted to proceed with the exercise on the injured side. The normal muscle thus always serves as a check or means of comparison which the patient may use if any doubt exists as to whether he is performing the exercise properly

FREE MOVEMENT —One of the fundamental rules of any program of muscle training or reëducation is to avoid fatigue of weak muscles. When muscles have been weakened by injury and long fixation, as in the case of patients with fractures, it is of the utmost importance to see that they are not required to do too much work when active exercises are first started Overloading of the muscle must be avoided, for either the muscle will become stretched and not respond satisfactorily or else it will quickly become fatigued, and in either case no real progress will be made toward building up its strength For every movement there are always at least two antagonistic sets of muscles to be exercised namely the flexors and the extensors, and it is important to plan the exercises so that each group gets its fair share of work. Otherwise gravity conspires to assist one of the movements and to resist the other, with the result that one set of muscles does insufficient work while the other set does too much work.

Free motion is planned to overcome this difficulty It is movement that is performed entirely by the patient s own muscles without assistance or resistance in either flexion or extension The influence of gravity upon the movement is eliminated as completely as possible by supporting the part on a smooth hard surface in such a position that both flexion and extension are performed in a plane horizontal to the earth s surface Thus free flexion and extension of the elbow may be carried out with the patient sitting and the arm supported at shoulder level on a smooth flat surface such as the top of a table. Both the forearm and upper arm should rest in contact with the surface during all stages of the movements Or these exercises may be given with the patient lying on the uninjured side and the elbow and forearm resting on the side of the chest. Free abduction and adduction of the shoulder are best performed with the patient recumbent on his back, the elbow flexed acutely and the upper arm resting on its posterior surface on a wide board with a polished surface. The advantages of free motion are exemplified in this movement particularly Patients who are totally unable to abduct the shoulder when standing which necessitates overcoming the force of gravity can often perform this movement quite well when recumbent. Free motion of flexion and extension of the fingers and wrist may be performed with the patient sitting and the hand resting on its ulnar border on the top of a table.

Free movements of the lower extremity are performed in a similar

manner usually with the patient lying In the case of the ankle free movement may be obtained with the patient recumbent on his side and the lower leg and foot supported by a smoothly polished board on either the medial or lateral surfaces Flexion and extension of the knee can be performed with the patient in the same position but with a broad board inserted between the legs, the injured extremity resting on its medial surface. Free motion of the hip in abduction and adduction is possible with the patient lying in a dorsal recumbent position The nearest approximation to free motion of flexion and extension of the hip is obtained with the supporting board between the legs shifted as high as possible into the perineum and the patient lying on the uninjured side.

Free motion has a definite place in the treatment of fractures It is chiefly indicated when the transition from passive to active movements is being made at the time when healing has progressed to the point of consolidation but when the callus is still soft and requires protection. The callus should not be subjected to the strain of bearing the unsupported weight of the distal part of the extremity nor is the muscular strength sufficient as yet to perform this amount of work Free motion provides support for both segments of the limb protects the fracture reduces the amount of work to be done by the muscles and at the same time permits active voluntary movement. The technic of free motion is individual and fussy however and is not likely to be used by any except very skilled physical therapists Practically speaking exercises performed in the recumbent position accomplish the purpose of free motion especially when supplemented by a little assisted movement, the weight of the extremity being supported by the physical therapist.

Assisted Movement —Assisted movement is the name used to designate motion that is performed by active contraction of the patient s own muscles but with outside assistance of one kind or another The assistance given may vary on the one hand from gentle support of the weight of the limb by the physical therapist with the purpose of producing an effect similar to that of free motion to on the other hand, the application of a considerable amount of force in trying to supplement and reënforce the patient s own muscles in forcing a motion to overcome a contracture or to stretch fibrous adhesions There is of course a great variation between these two extremes in the amount of force used and any intermediate degree of assistance may be given as well There is one common characteristic however to all degrees and types of assisted motion namely that the movement is always performed with the assistance of the patient s own muscular efforts never against it This distinction is of fundamental significance. If the patient s muscles oppose instead of assist the movement then it is no longer assisted but resisted motion and nothing but harm can result. Resistance is likely to be encountered

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when a very considerable amplitude of movement is present in the joint which is both free and painless. The second method of employing resisted movement may be used at a much earlier stage in the treatment of a fracture at the time when union is becoming firm and it is desired to begin active contraction of the patient's muscles. It utilizes the principle that it is easier for a patient to contract a muscle and resist movement than it is actually to perform the movement. It takes advantage of the reflex mechanism controlling the action of antagonistic muscle groups when motion is performed. The opposing muscle contracts only to play out slack as the movement progresses. This type of resisted motion helps to reëducate the patient's muscle sense and to reëstablish voluntary muscular control which has been lost as the result of injury or of prolonged disuse.

Resisted exercises may also be given very usefully with the aid of apparatus, the purpose here being to increase the amount of work done by certain muscles. While the distinction between assisted and resisted motion is a fundamental one and needs to be maintained, it breaks down and becomes of little practical importance when apparatus is employed. Thus a patient who practices flexion and extension of the elbow with the aid of a pulley exerciser performs resisted movements in flexion and assisted movements in extension. Similarly, when he exercises with a dumb-bell or Indian club he does resisted work when raising the club in the air and assisted work when the club is descending in the return motion. Riding on a stationary bicycle involves both resistive and assistive exercise. Actually this makes little difference in the late stages of fracture treatment so long as the fact is recognized and steps are taken to reverse the position and insure that the muscles that previously had assisted movement are now given resisted movement, while assistance is given to the muscles that previously worked against resistance.

The Application of Heat.—The application of heat is useful in the treatment of fractures under certain conditions but almost always in conjunction with massage and mobilization; alone it has little therapeutic effect. The rationale of the use of heat in any of its forms is the temporary production of a vascular dilatation in the part and a more rapid and abundant circulation of blood. In addition, heat has a definite soothing effect upon pain, the mechanism of which is not clear. The vascular changes resulting from the application of heat are probably more superficial than deep and also too transient to be able to influence the reparative process or to benefit fracture healing. On the other hand, the vasodilatation lasts long enough to permit massage and mobilization to profit from the greater vascularity in improving tissue nutrition and getting rid of the accumulated waste products of metabolism. The soothing and relaxing effects of heat are also beneficial as a preliminary to massage and mobilization, and their value has been established by clinical experience.

only when the joint is sensitive and the movement painful, and movement should never be forced under such circumstances. Here just as in the case of relaxed motion, thorough preparation is necessary, by means of gentle massage to obtain muscular relaxation and by a faultless technic on the part of the physical therapist in handling the limb so as to avoid pain, which inspires confidence in the patient.

Assisted motion may be given by the manual aid of the physical therapist, or apparatus may be employed such as the cord, weight and pulley a rod or dumb-bells Assisted motion offers great play for the inventive power of the physical therapist. A variety of procedures may be devised to accomplish a given purpose, and these have to be adapted to the needs and psychology of the patient. Benefit often results from teaching the patient to assist and reënforce his own muscular movement Thus he may assist supination of an injured forearm by rotating the wrist with the other hand, he may aid flexion of the hip by lying on his back, clasping his flexed knee with both arms and hugging the hip into extreme flexion, he may aid abduction of the shoulder by grasping the ends of a wooden rod with both hands the arms being by the side, and by a movement of adduction of the uninjured shoulder push the injured arm in the lateral plane away from the body, and he may use the body weight to assist in flexing the knee by standing holding on to the back of a chair bending the knees and squatting down as far as possible on the heels In general apparatus is of use only in direct proportion to the intelligence and determination of the patient and it is preferable whenever possible to devise methods of play or of work that will accomplish the same end and be more valuable because of the added element of interest. The latter method has the further advantage of teaching the patient to rely upon his own efforts and of stimulating his own initiative.

Gentle assisted motion is given in the early stage of fracture treatment in order to enable the patient to accomplish more than he could otherwise do by his own efforts. In the late stages of fracture treatment, strong assisted motion may be employed to overcome muscle contractures and scar adhesions in order to increase the amplitude of movement.

Resisted Movement.—Resisted exercises are intended to build up strength in weak muscles by increasing the amount of work to be done. They may be performed in one of two ways either by requiring the patient to perform a movement which is resisted manually by the physical therapist, or by the physical therapist making the joint perform a movement which is resisted by the patient. The first method is to be employed only in the late stages of fracture treatment, when dealing with muscles whose strength is already so far developed that they should be required to do more work than that represented by lifting the weight of the extremity and overcoming gravity It should only be used when there is no longer any danger of refracture and

during the period of sensitiveness and should be discontinued when function begins to return and active use is possible or at a much earlier period if the patient does not seem to be making sufficient effort on his own part for progress.

Continuous baking at a low heat is occasionally indicated in the treatment of fresh fractures when the circulation of the extremity is imperiled by vascular injury The vasodilatation may enable enough additional blood supply to get through to maintain viability pending the establishment of an adequate collateral circulation

Hot Baths —The warm whirlpool bath is the only form of hot bath that should be used by the physical therapist in the treatment of fractures. Its effects are obtained by the combination of heat and gentle superficial massage the latter being provided by the whirling currents Such baths are stimulating to the circulation and are useful in improving nutrition and when combined with active exercises performed while in the bath help in overcoming stiffness and in restoring function after fractures involving the distal portions of the extremities Obviously they are only indicated when union is sufficiently solid to permit the removal of all splints with safety

The hot bath or soak is a form of home therapy that is frequently prescribed for the general purpose of overcoming sensitiveness and encouraging the patient to move the part. Danger lies in the fact that it is often overdone and the prolonged soaking with the part dependent favors the accumulation of edema Contrast bathing with alternate soaking in hot water for one to two minutes followed by rapid immersion under cold running water is a much more valuable form of home therapy useful because in the words of Sir Robert Jones [23] it provides an exercise for the blood vessels of alternating vasodilatation and vasoconstriction and thus stimulates better vasomotor tone and counteracts any tendency for the accumulation of edema. Neither the hot nor the contrast bath should be given by the physical therapist, as both can be done with equal effectiveness and much greater economy at home

Diathermy —Diathermy has never been shown to have any specific action beyond that of producing heat centrally in the tissues Its soothing effect upon pain is therefore to be explained as the action of heat. In contrast, however with external heat that penetrates only superficially diathermy may at least in theory be focused so as to produce heat at any depth in the tissues Thus it is possible to generate heat in the region of the fracture and it appears plausible that the resulting hyperemia in and about the callus may be favorable to the deposition of calcium salts and hasten consolidation when it is being delayed by other than mechanical causes Granger [24] has reported good results from the use of diathermy in delayed union but his conclusions were based on the clinical observation of only a small

The use of heat however has been subjected to greater abuse probably than that of any other agency of physical therapy To turn on a radiant heat lamp or an electric baker is easy and keeps the patient occupied and the period of rest and relaxation under the soothing heat rays is the part of the treatment that the patient enjoys the most. If any part of the treatment is to be discontinued, he will willingly forego the part of the program that involves actual work but will want to retain the use of heat until the last. In consequence it often happens that heat treatments are continued for long periods after they have ceased to be beneficial and often at the expense of active mobilization the patient being lulled into a state of false contentment based upon the supposition that the treatment he is receiving will be the means of restoring function without any active effort on his part.

Not only may the use of heat be harmful in placing emphasis upon the least beneficial part of the treatment, but its prolonged use may be actually injurious to the tissues and result in pathologic instead of physiologic effect. Examples of the latter are unfortunately encountered all too frequently The appearance of a part that has been exposed to too much heat is characteristic and the entire story is revealed at the first glance The skin of the region that has been treated is mottled and irregularly pigmented The superficial tissues are hard and indurated to the touch. If the area is part of an extremity the distal portion is usually edematous and boggy I have had occasion to make incisions through such areas and have found the skin leathery and greatly thickened and the underlying tissues avascular and fibrosed The prolonged use of heat therefore defeats its own object and hinders recovery of function It should be used only for a definite purpose and over a short period when that purpose has been attained, it should be discontinued It should never be employed in conditions of nerve injury when there is the slightest disturbance of cutaneous sensibility In such cases burns are likely to occur in spite of the greatest care and the only safe rule is not to use it at all.

Heat may be employed in different ways for the treatment of fractures but the more important are radiant heat, hot baths and diathermy

RADIANT HEAT —The most convenient and generally used method of applying heat in the treatment of fractures is the electric radiant heat baker The single radiant heat lamp is much less effective and more time-consuming Electric baking is indicated in the early convalescent stage of fracture treatment as a preliminary to massage and mobilization All splints should be removed, the part placed in a comfortable position securely supported by pillows and sand bags as necessary and the heat turned on to a low degree of intensity The duration of the treatment should not exceed fifteen to twenty minutes and as a rule it should not be repeated more frequently than on alternate days. Electric baking should be employed only

on the lookout for unexpected developments Any unfavorable sign should be reported immediately

The surgeon should personally administer such physical therapy as is indicated in the early stage of fracture treatment As long as there is danger of displacement of the fragments and careful handling of the part and skillful management of the splints are required it is obviously unwise to delegate the treatment to a technician. It is only when the consolidation of the fracture is sufficiently advanced to reduce the risk of displacement and of other complications to the minimum that the services of the assistant may be employed The surgeon should continue to see the patient as frequently as necessary in order to observe the effects of the treatment to make such changes in the treatment as are from time to time indicated and to see that the patient is receiving adequate benefit from the treatment. Frequent consultations between the physical therapeutic technician and the doctor with the patient present, are necessary to avoid misunderstandings and insure progress

A great deal of responsibility devolves upon the technician in treating fractures. She must always bear in mind that the treatment is fraught with danger and that excess of zeal may result in harm She should keep a careful record of progress in each case measuring and recording the range of motion with the arthrometer Impressions of the range of motion are always unreliable. Accurate records of the arcs of motion are of great importance not only in showing whether or not treatment is beneficial and progress is being made but also in encouraging the patient and in giving him confidence that his treatment is being properly controlled The technician must also remember that while she has certain technical duties to perform as an operator her chief function should always be that of a teacher It should be her objective to educate the patient to an understanding of the relative importance of what is done for him and of what he does for himself and of the greater value of the latter When the proper moment arrives she must emphasize the importance of active use and encourage it in every way She should follow a consistent policy of not helping the patient any more than is absolutely necessary as for example in seeing that the patient removes and puts on his clothing without assistance. The performance of little tasks in connection with the toilet, the meals or certain household duties should be encouraged. At the same time the kind of physical treatment given the patient should reflect the gain in functional ability and should contain a large amount of active voluntary work

While active use of the part is the goal it must be remembered that this is dangerous at an early stage because it cannot be graduated or controlled The principle of treatment that should always be followed in building up strength in weak muscles is to keep the amount of work done below the fatigue point. When a weak muscle is required to do too much work or becomes overstretched it is likely to play out for a

group of treated cases, and it is difficult to prove that this was the factor that accomplished the result instead of other factors that were likewise concerned The action of diathermy in stimulating consolidation of a fracture must be regarded as distinctly *sub judice* until additional evidence has been obtained In the meantime, if the effect of diathermy is to be tried in cases of delayed union, it will be advisable to limit its use to those fractures where no mechanical causes exist to account for the retarded healing such as interposition of tissue between the fragments or lack of proper reduction and also to use it not later than three to four months after the injury Beyond this period the local situation in respect to callus formation has become so static that it is impossible to see how heat or hyperemia would be of any assistance. Immobilization of the fracture should not be discontinued during the period of treatment by diathermy, even though the presence of the splints interferes somewhat with the most efficient localization of the effect at the desired point. Granger solved this problem by cutting out windows in the plaster casings on opposite sides at the level of the fracture and applied the electrodes here. In other cases one electrode was placed on the extremity proximal to the cast or splint while the other was placed directly over the fracture The treatments should not be given more frequently than on alternate days and the duration should be about twenty minutes. If any effect is to be obtained from diathermy it should become manifest in four to six weeks and there seems to be no reason to prolong the treatment over a period of more than one month.

Aside from its purely experimental use in delayed union the writer is unable to find any other condition in fractures where diathermy is indicated which cannot be treated just as well if not better, by the application of external heat in one or another form In fact, a more extensive and superficial type of heat effect is to be desired as a preliminary to massage and mobilization than the deep localized heat effect of diathermy

The Technician and Muscle Reëducation with Reference to Fracture Treatment

The administration of physical treatment for fractures is time-consuming hence if it is to be employed efficiently and economically, resort must be had at certain times to the aid of trained technicians. To secure proper treatment requires the closest coöperation between the surgeon and the physical therapeutic technician. They are the two parts of a team, and the more harmonious the teamwork, the greater the benefit to the patient. Both have their own particular spheres, but each can reënforce the other's efforts. The surgeon is in charge and must assume the responsibility of directing the treatment. The technician's chief task is to carry out the doctor's orders but at the same time she should carefully observe the patient's reactions and be

has reached the maximum of improvement but should be taken much earlier at the time when the patient has developed enough motion and confidence to really go ahead and use the part From this point improvement is chiefly a matter of time with an occasional check-up and encouragement by the physician

The Treatment of Fractures in Specific Regions

Fractures of the Upper Extremity

Analysis of the function of the upper extremity shows that it is specialized and quite different from that of the lower extremity Freedom of movement and well coördinated muscular activity are the chief requirements While powerful muscular contractions may be required in the performance of many tasks such efforts are rarely long sustained and the characteristic activity is intermittent with alternating periods of work and rest. This is in marked contrast with the function of the legs where the task of bearing the body weight in standing and walking necessitates prolonged effort. Likewise the arms are used chiefly in lifting pulling pushing or twisting and the strain is one of leverage instead of end thrust as in the case of the legs

All function of the upper extremity centers about and is subservient to that of the hand The hand is the tool and the forearm and upper arm, together with the various articulations are merely the levers and gears that adapt the tool to its tasks and apply the power and provide the means of movement The usefulness of the upper extremity depends upon maintaining the delicate and multiple activities of the fingers and thumb If these are lost the result is almost as unfortunate as if the extremity were amputated

The treatment of fractures of the upper extremity must therefore be directed with the constant consideration of the necessity of preserving the mobility of the articulations and the suppleness of the muscles. In case of conflicting indications in the treatment of a patient, one should usually adopt the course that favors the retention of the greater amount of movement even if it is at the cost of a slight sacrifice of alignment Alteration of bony alignment in the upper extremity while undesirable and unesthetic, has little functional significance unless because of proximity to or involvement of a joint it causes limitation of motion Angular deformity does not have the same repercussions upon the articulations as in the case of the legs where due to the weight-bearing function it almost always results in joint strain and irritation But above all the motions and control of the fingers and thumb must be preserved

Because of the need of preserving movement and control physical therapy is called upon to play a prominent part in the treatment of fractures of the upper extremity Early massage and mobilization may be employed by the surgeon under almost ideal conditions in many of

considerable period of time. Hence, a weak muscle should always be employed in a partially shortened position, and the amplitude of the movement should be increased only proportionately with the gain in power of the muscle Herein lies the danger of uncontrolled active use of a part at a time when the muscles are still weak from injury and lack of use The patients fail to progress and complain of pain, and examination shows a decrease rather than a gain in movement. The remedy here is to rest the muscle, not to exercise it more.

All of the various types of motion that have been previously described blend into each other more or less so far as their use is concerned. There is no one moment when one should change from passive to assisted motion, or from the latter to resisted movement or to active use. On the contrary the use of the different kinds of motion should overlap and the transition from one kind to the other be made gradually In general one should begin with muscle setting and a little passive motion as early as possible. As soon as the consolidation of the fracture permits, the passive movements should be supplemented by a little gentle assisted motion or free motion A short session of resisted exercise with the patient resisting and the physical therapist making the movement, will aid in establishing the control of the muscles and prepare the way for gentle assisted movements. As quickly as possible, active exercises with and against gravity should be added and the frequency and amplitude of the movements increased. Finally when active use of the part has been permitted, resisted exercises should be employed with the patient performing the movement resisted by the physical therapist, and forced assisted movements should be added to attain the last degrees of joint motion

When the stage of treatment has been reached when all splints and apparatus have been discarded the general purpose of the treatment should be to show the patient exercises that he is to perform at home systematically and to reserve the balance of the session for doing things that the patient cannot do as well by himself Active exercises can often be done better if performed simultaneously with both extremities and for this reason many of them should be performed, using both sides Means of using the injured part should be suggested to the patient. For example, in the case of the upper extremity dishwashing sweeping writing sewing typing or driving a motor car may be advised. For the lower extremity walking, gardening and working the pedal of a sewing machine jig saw or bicycle provide valuable exercise Games may be suggested such as golf swimming or playing various musical instruments that will exercise the part.

In the early stages of fracture treatment physical therapy should be employed at fairly frequent intervals Treatments given every other day are usually fully as satisfactory and obtain as rapid progress as daily treatments. As strength and movement improve the sessions should be dropped down to twice a week then once a week and finally discontinued This latter action should not be delayed until the patient

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these fractures, particularly those of the phalanges lower end of the radius, shaft of the humerus and upper end of the humerus This treatment must be preceded by proper reduction of the fracture, and combined with adequate protection When properly employed, physical therapy will sometimes determine the difference between a good and a bad result In seeking to bring about functional recovery after a fracture of the upper extremity, it is of the greatest importance to regard the limb as a whole and to avoid focusing the attention only upon the region immediately adjacent to the injury Stiffness of the fingers and hand with loss of function may well follow an injury involving a region as remote as the shoulder, and stiffness in the region of the shoulder may be the consequence of an injury affecting the wrist. In the application of physical therapy it is therefore important to treat all the joints and muscles and to restore all motions It is also necessary to inspire the patient with the will to work. No amount of physical therapy will make up for the persistent avoidance of movement by the patient. In personally administering massage and mobilization in the early stage of treatment the surgeon has an unequalled opportunity for impressing upon the patient the importance of movement in reëstablishing function and the necessity for active coöperation on his part If the surgeon fully capitalizes this opportunity a large part of the disabilities due to stiffness of the fingers and other joints will be avoided.

Fractures of the Hand.—Fractures of the region of the hand include injuries of the phalanges and metacarpals These injuries, unfortunately are commonly considered minor and are often treated by physicians of little experience whereas actually they represent problems of the first magnitude and demand the highest skill in their solution Frequently multiple and involving the bones of several fingers as well as of the hand the results are often distressing and necessitate the later amputation of one or more digits in order to get rid of an impediment to the function of the remaining fingers The common causes of failure in so far as they may be ascribed to treatment, are incomplete reduction too long fixation and lack of physiotherapeutic reëducation of the patient

Phalangeal Fractures —Phalangeal fractures if accompanied by bony deformity require immediate reduction and splinting Alignment is usually best maintained with the joints fixed in flexion. This position overcomes deforming muscle pulls and likewise favors the recovery of motion Traction must frequently be applied either by means of adhesive plaster applied to the skin or by a needle or wire passed through a phalanx. Constant traction is usually secured in combination with some form of the banjo splint Many of these fractures are compound with extensive injury of the tendons and soft tissues and

inevitably result in joint stiffness due to adhesion of the tendons in spite of the best treatment.

The point of chief importance in the treatment of these injuries after securing reduction is to reduce fixation to the minimum. Union develops rapidly and at the end of two weeks there is very little risk of displacement Physical therapy may be started at the end of one to two weeks depending upon the nature of the injury the splints being removed temporarily for treatment. In fractures without deformity it may be employed from the beginning All splints should be removed at the end of three weeks and active movement and light use permitted.

Physical therapy should consist of the warm whirlpool bath, followed by superficial massage and relaxed motion of all the digits The uninjured fingers should receive treatment as well as the injured ones. Active motion with the injured phalanx supported manually should follow with movement through as great an arc as possible The movements should be performed individually for each of the joints The treatments should be repeated daily for the first week or two and thereafter on alternate days. At the end of three to four weeks only active or assisted movements should be made and thereafter chief reliance should be placed upon supervised active use. Contrast bathing of the hand at home is also useful. The patient should be given exercises of squeezing a rubber or woolen ball, and shifted gradually into playing scales on the piano typing and other kindred activities Physical therapy after five weeks is usually a waste of time

Metacarpal Fractures —Fractures involving the shafts of the metacarpal bones in contrast to those of the phalanges rarely give rise to functional impairment. They are usually accompanied by posterior angulation or bowing and by dropping of the knuckle This deformity may usually be corrected by flexion of the metacarpophalangeal joints to relax the pull of the volar interossei muscles and by pressure from the palmar side against the head of the metacarpal These indications are met by flexing the fingers over a molded splint or roller bandage and fixing them in this position Fixation must usually be maintained for about three weeks. As a rule, there is little difficulty in the recovery of finger function and formal physical therapy is rarely needed. Contrast bathing at home, active exercises and use are generally adequate.

Fractures of the heads of the metacarpals and multiple fractures of the phalanges and metacarpals are much more serious and frequently require constant traction for the correction of deformity accomplished usually by some form of the banjo splint. This treatment is dangerous from the functional standpoint and may lead to stiffness in comparison with which a little bony deformity may seem of slight importance. The stave fracture of the proximal end of the metacarpal of the thumb usually designated as Bennett s fracture, is likewise of functional significance because it implicates the joint and

may cause impairment of, or pain on, motion These fractures require traction to accomplish reduction with the thumb in the position of wide abduction and partial apposition Traction must usually be maintained for a period of about three weeks before sufficient union is obtained to prevent recurrence of the deformity

Physical therapy is distinctly indicated in the cases of multiple fracture of the bones of the hand and likewise after fractures of the metacarpal heads and Bennett's fracture. The treatment should be started just as soon as traction is discontinued, usually at the end of two to three weeks It should consist of the warm whirlpool bath, massage, passive assisted and active movements of the interphalangeal and metacarpophalangeal joints Intensive treatment should be given daily during the first week or two if there is much tendency to stiffness. Active exercises to be done at home, as well as under the supervision of the technician, and contrast baths should be prescribed at the end of four or five weeks. Thereafter the patient should be constantly urged to active use and exercise of the fingers and hand, and some form of suitable occupational therapy should be suggested, such as piano playing typing knitting sewing cutting out paper patterns, etc. and these should be persisted with until the stiffness has entirely disappeared.

Fractures of the Carpal Bones.—The most common injuries of the carpal bones are fracture of the scaphoid and dislocation of the semilunar These may occur separately or in combination. Instances of fracture of the other carpal bones are occasionally seen but such lesions are rare and not typical The principles of treatment necessary for a successful result after carpal fractures are first early diagnosis secondly immediate reduction of displacement when present, and thirdly long-continued immobilization and protection of the fractured region Physical therapy is usually contraindicated.

Fractures of the Scaphoid —The common injury of the scaphoid bone is a transverse fracture through the 'waist' usually not associated with much separation or displacement of the fragments except when accompanied by dislocation of the semilunar bone in which case the distal fragment is displaced posteriorly along with the distal row of the carpus and comes to lie in a dorsal relation to the proximal fragment and the semilunar

Fractures of the scaphoid bone constitute a class apart from other bony injuries because of their notorious tendency to nonunion. This is due to the fact that the blood supply to one of the fragments usually the proximal is shut off and that bony union can only be brought about by the ingrowth of capillaries from the viable fragment and creeping substitution of the dead bone by living bone. The closest approximation of the fractured surfaces and avoidance of all motion between the fragments are the necessary conditions for the

completion of this process The anatomic studies of Berlin [21] showed that the fragments were brought into closest apposition when the wrist was placed in a position of 45 degrees dorsiflexion with radial deviation Fixation of the wrist in this position should be secured by the application of plaster splints extending from below the elbow to the metacarpophalangeal joints and including the first phalanx of the thumb A policy of complete immobilization of the wrist should be followed for a period of six weeks

When fractures of the scaphoid are subjected to movement the result is almost invariably nonunion. For this reason physical therapy is completely contraindicated until after the splints have been removed During the period of complete fixation of the wrist the fingers may be used in so far as permitted by the splints and many tasks of a light nature may be performed with benefit in respect to the maintenance of finger flexibility Following the removal of the splints it is advisable for the patient to wear a steel reenforced leather brace extending from the metacarpophalangeal joints to the middle of the forearm but leaving the fingers and thumb free. This may be removed daily for contrast bathing and active exercises of the wrist in flexion and extension and of pronation and supination of the forearm. Above all active use of the hand for all tasks with the brace in place should be urged This is the best form of physical therapy and many patients have been able to resume their regular work often of a heavy nature without being handicapped by the brace The brace can usually be discontinued at the end of three months and at this time there is generally complete restoration of function

Dislocation of the Semilunar Bone.—While it is our purpose to consider in this chapter fractures rather than dislocations anterior luxation of the semilunar bone requires mention because of its frequent association with fracture of the scaphoid. The treatment of isolated dislocation of the semilunar bone is reduction by either the closed or open method as soon as possible after the diagnosis has been made. When the patient is seen early that is within three or four days of injury reduction can usually be accomplished by the closed method When seen later reduction can usually only be brought about by open operation When the patient is not seen until three or four weeks after the injury it is usually advisable to excise rather than to replace the dislocated bone

Following reduction by either the closed or open method the wrist is splinted in a position of dorsiflexion for a period of about four weeks but the fingers and thumb are left free During this period active use of the fingers and thumb should be urged for all tasks and if full coöperation is obtained the patient will appear to be handicapped very little by the presence of the splints Due attention should also be paid to the prevention of stiffness in the elbow and shoulder Upon removal of the splints function of the wrist is usually quickly

reëstablished by active use supplemented by contrast bathing and active exercises performed at home As a rule, there is little need of formal physical therapy administered by a technician except in the case of long-standing dislocations when the displaced semilunar must be excised In such cases there is apt to be considerable stiffness of the wrist and fingers associated with pain and these conditions can be ameliorated by whirlpool baths, massage, and active and passive exercises, beginning as soon as the healing of the operative wound permits.

When dislocation of the semilunar is associated with fracture of the scaphoid reduction should be brought about by the closed method, and the after treatment differs in no way from that of isolated fracture of the scaphoid

Fractures of the Lower End of the Radius.—Fractures of the lower end of the radius are, with the exception of fractures of the clavicle, the most frequently encountered of all bony injuries and constitute a large and important group of fractures Included in the group are several different types of fracture which may be differentiated both on an anatomic and mechanistic basis, but it is not within the scope of this chapter to deal with each of these separately By far the most common type of fracture is that produced by a fall on the outstretched hand with the wrist in the position of dorsiflexion, or by a blow on the palm as from backfiring while cranking a gasoline motor, the wrist being in the same position This fracture mechanism was first described by Abraham Colles [26] and is usually known by his name. Our discussion will be limited to a consideration of the physical treatment of Colles fracture and also of the fractures of the lower radial epiphysis likewise an important group

Colles Fracture.—By the term *Colles' fracture* we mean to designate fractures through the lower cancellous end of the radius produced with the wrist in hyperextension. The pathology of this fracture is well known and requires no special description here beyond calling attention to the fact that it may be transverse and not involve the articular surface or comminuted with extensive involvement of the joint surface Impaction according to Darrach is present in about one-third of the cases. Deformity may be absent but is generally present and often to an extreme degree. It consists of a posterior displacement of the distal fragment which is at the same time tilted so that the articular surface faces backward and distally instead of forward and distally The distal fragment is also rotated in the direction of supination on the long axis of the radius. The displacement of the distal fragment causes disruption of the inferior radio-ulnar articulation with either the tearing of the triangular fibrocartilage or a fracture of the ulnar styloid to which it is attached. This frees the distal

fragment from the head of the ulna, and the latter is left projecting on the volar surface of the wrist

The treatment of this fracture involves two problems first, that of correction of the bony deformity and second that of obtaining functional restoration. The solution of these problems is by no means identical and demands not one but two answers It does not follow that because bony deformity is corrected functional recovery will be the natural sequence nor on the other hand can it be predicted that a fracture with uncorrected bony deformity will not in the end provide a strong and useful wrist Anatomic restoration is the proper foundation for functional recovery but it is necessary to work for the latter not to wait for it

Correction of displacement is of fundamental importance in the treatment of these injuries and should be brought about by the closed manipulative method under local or general anesthesia as soon as possible after the injury Impaction should be broken up the distal fragment pushed forward into normal relation with the head of the ulna and the backward tilting and rotation corrected Reduction should be maintained by the application of retentive splints These should extend from the metacarpophalangeal joints to the upper forearm leaving the thumb and fingers free for all movements. In this connection it is important to realize that the level of the metacarpophalangeal joints is on a line about one inch proximal to the web of the fingers and corresponding to the distal transverse crease in the palm If the splint projects beyond this point, flexion of the fingers will be hindered and functional recovery delayed The test of complete freedom of finger movements is whether the tip of the thumb can be approximated to the tips of all the fingers As a rule the wrist must be fixed in moderate flexion with the forearm pronated Our own preference for splinting is anterior and posterior plaster splints because of the ease of molding and adapting them to the parts and their light weight and small bulk. A sling completes the dressing

Physical therapy plays an important rôle in the treatment of Colles fractures Routine surgical care of the splints is not sufficient and will result in many stiff disabled hands and delayed convalescence unless supplemented by treatment specifically directed to promoting recovery of function My own practice is to begin light superficial massage and passive mobilization the day following the reduction. Prior to the reduction when there has been considerable swelling I have administered massage for about twenty minutes often with noticeable improvement in the circulation The day after the reduction the dorsal splint is removed leaving the wrist resting on the anterior splint which is supported on a cushion Light rhythmical stroking is administered over the entire back of the hand wrist and forearm. The dorsal splint is then reapplied and an assistant lifts the patient's wrist, holding it against the splint while the anterior splint is removed and the anterior surface of the wrist and forearm similarly treated. The

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Fractures of the Lower End of the Radius.—Fractures of the lower end of the radius are with the exception of fractures of the clavicle, the most frequently encountered of all bony injuries and constitute a large and important group of fractures Included in the group are several different types of fracture which may be differentiated both on an anatomic and mechanistic basis, but it is not within the scope of this chapter to deal with each of these separately By far the most common type of fracture is that produced by a fall on the outstretched hand with the wrist in the position of dorsiflexion, or by a blow on the palm as from backfiring while cranking a gasoline motor the wrist being in the same position This fracture mechanism was first described by Abraham Colles [26] and is usually known by his name. Our discussion will be limited to a consideration of the physical treatment of Colles fracture and also of the fractures of the lower radial epiphysis likewise an important group

Colles Fracture.—By the term *Colles' fracture* we mean to designate fractures through the lower cancellous end of the radius produced with the wrist in hyperextension. The pathology of this fracture is well known and requires no special description here beyond calling attention to the fact that it may be transverse and not involve the articular surface or comminuted with extensive involvement of the joint surface. Impaction according to Darrach is present in about one-third of the cases Deformity may be absent but is generally present and often to an extreme degree. It consists of a posterior displacement of the distal fragment, which is at the same time tilted so that the articular surface faces backward and distally instead of forward and distally The distal fragment is also rotated in the direction of supination on the long axis of the radius The displacement of the distal fragment causes disruption of the inferior radio-ulnar articulation with either the tearing of the triangular fibrocartilage or a fracture of the ulnar styloid to which it is attached. This frees the distal

fracture of the lower end of the radius in children usually between the ages of seven and twelve years Such fractures require careful reduction and retentive splinting for a period of about four weeks The same methods are employed as in the treatment of Colles fracture, although greater difficulty may be encountered in retaining reduction than in the latter There is less need for physical therapy in the treatment of the epiphysial fractures than in Colles fracture on account of the youth of the patients which is favorable to the rapid recovery of function The physician may begin the administration of massage and relaxed movement at the end of two weeks, and this should be continued on alternate days until the splints are removed Active use of the splinted hand the fingers having been left free should be encouraged from the end of the first week As soon as the splints have been removed contrast baths should be given at home together with regular exercise treatment until recovery is complete Usually there is no necessity for formal baking and massage treatments

Fractures of the Bones of the Forearm.—Fracture of Either the Radius or Ulna Alone.—Fractures involving the shaft of one of the bones of the forearm the other remaining intact are, on the whole fairly simple problems The degree of displacement is rarely severe due to the fact that the unfractured second bone serves as a splint and exerts a limiting action. The bony deformity can generally be corrected by closed methods although occasionally open reduction may be required Fixation is usually obtained by the application of retentive splints extending from the metacarpophalangeal joints nearly to the axilla with the elbow flexed either at a right angle or in complete extension and the forearm in varying positions of pronation or supination depending upon the type of fracture.

Physical therapy may usually be employed from about the fourteenth day after injury Earlier treatment is likely to be dangerous Active exercise and use of the digits should however be insisted upon from the beginning At the end of two weeks superficial massage may be employed the arm being supported on one splint while the other is removed Depending upon the location and mobility of the fracture relaxed motion may be performed at either the wrist or elbow choosing the articulation farthest removed from the seat of injury At the end of three to four weeks depending upon the progress of callus formation the arm may be carefully lifted from the splints supported by cushions and more general treatment administered in the form of superficial massage with relaxed motion of the fingers wrist and elbow Generally the last movements to be performed are those of pronation and supination as these are attended by the greatest danger of displacement The physician should be guided as to these by the appearance of callus formation by roentgen rays and he should wait until there is clear evidence of new bone formation The duration of splinting is variable in fractures of one of the bones of the forearm In

fingers are massaged individually and then mobilized passively and actively with assistance The splints are then reapplied and bandaged in place The elbow is next flexed and extended, and the shoulder abducted and rotated The patient is instructed to exercise the fingers, the elbow and shoulder regularly every day The treatment is repeated the following day, and thereafter on alternate days At the end of four days the patient is instructed to lift the splinted wrist out of the sling whenever sitting and to begin to use the fingers for light tasks such as holding a newspaper, turning the pages of a book, and in connection with the toilet dressing, undressing etc.

At the end of one week the wrist is lifted out of the splints during the treatment and supported on a cushion Following the massage of the dorsal surface the region of the fracture is supported by one of the physician's hands while with the other gentle relaxed motions are made of extension and flexion of the wrist, and of pronation and supination of the forearm. While the wrist is supported in extension the patient is requested to extend repeatedly the fingers and to clinch them in a fist. Attention is also given to the elbow and shoulder At this time, also the patient is instructed to discontinue the use of the sling elevating the hand only when the fingers become swollen as a result of the dependent position Active use of the hand is increased to include assistance in eating dressing shaving or caring for the hair

At the end of two weeks the use of heat, either by an electric baker or from a whirlpool bath, is begun as a preliminary to massage and mobilization The extent of the movement is increased, and active and assisted movements occupy a larger part of the treatment but the region of the fracture is still supported manually At this time the anterior splint is discontinued and the wrist and forearm are bandaged into the dorsal splint only This permits a greater range of active use of the fingers All splints are discontinued at the end of three weeks except in the severely comminuted fractures, which usually require protection until the end of four weeks. Temporarily after the removal of the splints the patient's comfort is promoted by the use of a bandage about the wrist or by a leather wrist strap From this time on the patient employs contrast bathing at home performs active exercise and is encouraged to use the hand actively for all tasks except lifting or pushing He is required to report twice a week during two additional weeks for supervised treatment by the technician.

Functional recovery is usually complete by the end of six weeks, and a surprising variety of active use of the hand is usually possible for some time earlier

Fractures without displacement require splinting for two weeks only, and the whole plan of treatment in respect to movement and use may be speeded up correspondingly

Epiphysial Fractures of the Lower End of the Radius.—Separation of the lower radial epiphysis occurs as a variation of

treatment lies in a correct appraisal of the pathologic changes and the amount of bony deformity and whether or not the displacement is of a type to cause interference of movement If it is then the only remedy is operation with the removal of the loose fragment if the remainder of the head is still capable of function or with complete excision of the head if there has been extensive comminution of the head or a displaced fracture through the neck of the radius In the case of the rare epiphysial fractures of the upper end of the radius occasionally encountered in children open reduction may be performed instead of excision.

When fractures of the head or neck of the radius are treated either by removal of the loose fragment or by excision of the head no splinting is required beyond soft dressings bandage and sling The problem of securing union of the fracture has been eliminated by the removal of the fragments and the reparative process is limited to the healing of the raw bony surface and damaged soft parts Passive and assisted movements of limited extent may usually be begun at the end of three to four days and the patient may be encouraged to perform active pronation and supination as soon as he has recovered from the acute effects of the operation As soon as wound healing has been obtained usually at the end of one week, the active efforts of the patients may be aided by electric baking superficial massage and effleurage and by relaxed and assisted movements of the elbow Usually the arm may be removed from the sling for the performance of light tasks at the end of three weeks and at the end of four weeks this support is removed and active use encouraged Physical therapy should usually be continued until the end of eight weeks with radiant heat, effleurage active exercises and forced assisted movements

Fractures of the head and neck of the radius with little or no displacement usually require splinting with the elbow in the position of acute or right angle flexion for a period of about three weeks Superficial massage and relaxed motion of the elbow in flexion and extension may be administered however from the beginning the splint being removed for the treatment. As a rule the rotary movements of the forearm which are the most painful and likewise the most dangerous in respect to causing displacement should not be started until the end of one to two weeks the indication here being the disappearance of pain on motion At the end of two to three weeks more intensive treatments can generally be given consisting of radiant heat effleurage assisted and active movements. Fairly complete recovery after such injuries ought to be obtained in from six to eight weeks although there may be an obstinate limitation of complete extension of the elbow persisting for several months before it finally disappears

Special warning ought to be given in connection with fractures of the head and neck of the radius of the danger of the development of an ossifying hematoma or myositis ossificans Many of these fractures are complicating injuries of posterior dislocations of the elbow

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Fractures of Both Bones of the Forearm —Fractures of both bones of the forearm are among the most difficult of all fractures to treat. They are frequently attended by severe displacement, reduction is difficult and often necessitates resort to the open method, and in addition union is frequently delayed. Under these circumstances physical treatment is dangerous and the only safe rule is to postpone it until consolidation is well advanced During the interval, efforts should be concentrated upon obtaining mobilization of the fingers and thumb with the splints in place This task is often difficult enough but at the same time of extreme importance, as the muscles arise in or span the region of the fracture and have often suffered considerable damage Unless motion is started early and continued, there is likely to be resulting stiffness which may imperil the functional result. The splints should be trimmed well back into the palm in order to allow unhampered motion of the digits In addition exercises of the shoulder that put it through its full range of motion should be performed regularly

The time required for union of fractures of both bones of the forearm may vary from six to ten weeks or even longer It is generally advisable to follow a policy of complete fixation of the fracture until this result is obtained. Relaxed movements of the wrist and elbow preceded by gentle stroking massage may usually be started one to two weeks before the removal of the splints. The movements of pronation and supination are the most difficult to recover and indeed are often permanently restricted in greater or lesser degree depending upon whether or not the reduction has been complete the amount of callus formation, and the extent of soft part injury and scar development in the interosseous space The amount of assistance that may be given in recovering these motions depends upon the surgeon's appraisal of the causes of limitation and how completely these may be overcome by gradual stretching After removal of the splints, baking, effleurage and assisted movements may be given and active use prescribed As a rule after two to four weeks of treatment reliance should be placed upon active exercise, and the other forms of physical therapy stopped.

Fractures of the Elbow —Fractures of the Head and Neck of the Radius —Fractures of the head and neck of the radius carry the menace of restriction of the rotary motions of the forearm and limitation of flexion and extension of the elbow and demand special attention in order to preserve complete function The crux of the

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operation was unnecessary His results were confirmed by Pirie Watson [14] who published the records and roentgenograms of two patients whom he had treated by Lucas-Championnière s methods In both cases there was well marked separation of the fragments in the beginning but bony union was obtained although with some deformity Recovery was stated to have been complete in from four to six weeks The elbows were enveloped in cotton wool dressings and supported in slings at a right angle massage and mobilization were started immediately Both Lucas-Championnière and Watson laid great stress upon the necessity of pressing the proximal fragment against the distal with the fingers during motions of extension otherwise the proximal fragment was likely to become adherent to the underlying tissues and thus interfere with function of the triceps

Fractures of the olecranon process without displacement may be treated in a sling with only bandage support or at the most in extension with a straight splint for one week followed by a sling Massage and mobilization should be started immediately the motion being of the relaxed type for the first two weeks followed by assisted and active movements. Use may be permitted at the end of four weeks

Fractures of the Lower End of the Humerus —Fractures of the lower end of the humerus include a variety of injuries and it is necessary to consider these separately as the problems are different.

Supracondylar or Diacondylar Fractures —The majority of these fractures are encountered in children The injury is generally diacondylar that is transverse at the level of the condyles rather than supracondylar or above the condyles The fracture line slopes obliquely downward from behind forward and except in the rare injuries of the flexion type the distal fragment is displaced posteriorly When satisfactory reduction is obtained and even sometimes when it is not, the end results are almost always excellent with complete recovery of motion The carrying angle may be somewhat altered but this is of functional significance only when it is decreased, not when it is increased The recovery of complete extension of the elbow is often slow but with time it almost always becomes complete or at the most lacks only a few degrees of normal.

Reduction should be accomplished as early as possible after injury by the closed method with the aid of anesthesia. Reduction is maintained by fixing the elbow in the position of acute flexion either by bandage or by a posterior plaster splint Care is necessary in watching the circulation both during the reduction and afterward as this injury is the most common cause of the dreaded Volkmann s ischemic contracture Whenever there is an absent radial pulse or when the pulse disappears during the reduction or when there is marked swelling correction of the bony deformity should be postponed and measures taken to improve the circulation When the hand is cold and white and motion of the fingers cannot be obtained and the pulse is absent, an

with accompanying rupture of the capsular ligaments and hematoma formation The fracture of the upper end of the radius adds to the hemorrhage and releases bone-forming elements in the traumatized tissues, which offer ideal conditions for widespread ossification. The additional trauma of operation may further stimulate this process. Certain it is that extensive calcification in the anterior capsule is seen not infrequently in these fractures, particularly those that have been subjected to operation and it may cause interference with function and sometimes complete ankylosis The characteristic symptoms are diminution of motion just at the time when an increase should be expected pain on use, and evidence of muscle spasm. The diagnosis is confirmed by roentgen ray examination which shows cloudiness or beginning ossification in the soft parts anterior to the elbow When the development of this condition is suspected or found, the elbow should be immediately immobilized with cessation of all physical therapy and of activity of any kind that may represent a source of irritation Only when the process of ossification has reached an end-point can anything be done to overcome the condition Then baking, massage, and active exercises may be started and active use resumed. After an interval of one year, if considerable limitation of motion persists, the area of calcification can be excised with good chance of cure.

Fractures of the Olecranon Process —The treatment of fractures of the olecranon process depends upon whether or not there has been separation of the fragments In fractures with displacement the situation is analogous to that in fracture of the patella and we believe that the best results are obtained by operative replacement of the fragments and suture The purpose of the operation should be to fix the fragments so securely that movement may be permitted immediately without the necessity of external fixation The suture material must therefore be strong enough to withstand considerable strain, and we favor the use of either fascia lata or wire. When the fragments are drilled and snugly approximated with these materials then the elbow may be flexed and extended without danger and no postoperative fixation is required beyond that provided by a large soft dressing and sling Active and passive mobilization may be started as soon as the acute operative reaction has subsided. Massage may be administered as soon as the wound has healed and after two weeks, may be followed by assisted movements and active exercises in flexion and extension of the elbow Active use may be permitted at the end of four weeks and complete functional recovery is usually obtained in from eight to twelve weeks

It is only fair to add that Lucas-Championnière,[37] who to his last days was an ardent advocate of the operative repair of fractures of the patella and who earlier advised operation also for fractures of the olecranon came later to feel that the results obtained by his method of massage and mobilization in the latter injuries were so good that

joint capsule representing the spreading of ossification from small fragments evulsed with the capsular ligaments Occasionally these calcified bodies must be removed but this should only be done after thorough efforts have been made to restore function and it has been established that they are responsible for the persistent disability

Uncomplicated fracture of an epicondyle is usually a simple injury best treated by a sling and bandage Massage and relaxed motion may be started immediately in adult patients but is scarcely needed in children. Active motion may be permitted at the end of one week and the sling may be discontinued at the end of two or three weeks The fragment frequently fails to unite by osseous union but this rarely gives rise to any symptoms

Condylar and Intercondylar Fractures —Fractures involving a single condyle either the medial or lateral or of both the condyles in the form of the intercondylar T type are difficult injuries to treat and rarely recover without some degree of functional impairment. Accurate reduction should be sought by all possible means but the problem is individual in each case and no general rule can be laid down. Even the experienced surgeon must often proceed by the method of trial and error The displacement may be insignificant in which case no reduction may be required but this is rare. In others it may be possible to secure satisfactory reduction by the manipulative method followed by fixation of the elbow in whatever position of flexion or extension seems best to retain the correction In other cases continuous traction may be indicated by means of adhesive to the skin of the forearm or Kirschner's wire through the olecranon process or it may be advisable to perform an open reduction In some of the more difficult cases all of these methods may be tried in rotation and the result may still remain unsatisfactory While reduction is important, prolonged fixation of these fractures is unwise and will result in stiffness of the elbow regardless of the perfection of the reduction Some compromise has to be reached and this generally resolves itself into a choice between two plans of treatment first to secure reduction by manipulation or traction and to begin mobilization at the end of two to three weeks which is too early to render exercise treatment entirely safe or second to obtain reduction by operative means with internal fixation of the fragments by one or another method but secure enough to allow of doing away with external splinting and of beginning mobilization of the elbow as soon as the acute operative reaction has subsided. The latter course has much to commend it, but it often proves impossible to reduce the fragments perfectly and the additional trauma of the operation may occasion secondary fibrous tissue formation sufficient to impede complete recovery

In case of extensively comminuted fractures or in elderly individuals with injuries of a more simple type it may well be the best policy not to aim for reduction which would be imperfect at best but instead to try to develop function by employing massage and mobilization from

incision should be immediately made at the front of the elbow to expose and release the vessels and to evacuate the hematoma and relieve the tension

In the uncomplicated fractures the dressing should be taken down at the end of 48 hours and the elbow inspected In the absence of blebs light stroking massage may be administered over the lateral, medial and posterior surfaces, and the elbow may be passively extended and flexed through a range of 10 to 20 degrees, the dressings are then reapplied This treatment should be repeated on alternate days over a period of about three weeks, gradually gaining in extension until the right angle position is attained At this time the splint or other dressings may usually be removed and a neck sling substituted, which is gradually lowered to the right angle At the end of four weeks the mother may begin to remove the arm from the sling twice a day and assist the child in performing active exercises At the end of four to five weeks all support may be discontinued and active use encouraged.

The difficulty in the use of physical therapy in this fracture is the age of the patient and the child s timidity and fear of pain The confidence of the child can be obtained only by being careful not to cause pain at any time, by being patient and by not hurrying If scenes result in spite of every effort it is better to give up all efforts at physical therapy Also because of the fact that most of the patients are children there is always the danger of a fall during play and of secondary injury and this makes it necessary to protect the fracture for a longer period than would otherwise be necessary

Lindsay [28] has reported successful results from the early use of massage and relaxed motion in fractures of the elbow employing a more radical technic than we have followed I have had the pleasure of seeing some of Lindsay's cases and the results appeared to correspond in every way to what he had claimed. I feel, however, that it is a very specialized technic and hardly safe in ordinary hands In general children recover so rapidly and completely after supracondylar fractures that it is unnecessary to take any risks with them.

Fractures of the Epicondyles—Fracture of the medial epicondyle, either in the form of a simple fracture or of an epiphysial separation, is a common injury while fracture of the lateral epicondyle is rare. It is a frequent complication of dislocation of the elbow but gives rise to no difficulty unless it becomes caught in the intra-articular space during the reduction in which case, because it carries the ulnar nerve with it, there is likely to be injury of the nerve with the characteristic paralysis An immediate roentgen ray examination should be made following the reduction, to guard against this complication, and when the fragment is shown to be lying in the cavity of the joint, its removal by operation is indicated together with transposition of the nerve to the front of the elbow Another complication of fracture with dislocation is the development of calcified bodies in the medial portion of the

advantage in attempting manipulative reduction with the aid of an anesthetic in the hope of being able to enmesh or to interlock the frag ments When successful the after treatment is simplified when un successful nothing has been lost. When the fracture is either of the oblique or comminuted type manipulative reduction is foredoomed to failure and ought not to be attempted In these cases light superficial massage should be administered to relax the muscles and then with out any anesthesia the angular deformity should be gently corrected and the coaptation splints and the dressings applied. As a rule no great difficulty is experienced in controlling the alignment in this manner and as the spasm of the muscles is overcome by daily massage treat ments the reduction becomes more and more perfect the weight of the unsupported elbow providing a certain traction force If any diffi culty is experienced in obtaining reduction, particularly in the oblique or transverse fractures it is usually because tissue has been interposed between the fragments and this is an indication for operative reduc tion usually with internal fixation of the fragments by one or another method Following operation rigid splinting should be employed for the first two weeks but after this massage and mobilization may be begun.

When possible treatments should be given daily during the first two weeks and thereafter on alternate days They are best given with the patient seated, the back supported and the forearm resting on a cushion laid across the patient s knees Massage of the superficial type should extend from the wrist to the shoulder and after relaxation is obtained gentle passive movements of the elbow and shoulder should be performed also not neglecting the fingers and wrist. The motions of the shoulder should be made with the elbow and forearm supported by the physician s hands and carefully and in a limited way in order not to cause movement of the fragments The last movements to be started are those of rotation of the shoulder and these should generally be postponed until the end of ten days All of the early treatment demands the greatest skill and judgment and ought not to be administered by any one but the physician in charge. Healing progresses rapidly and the changes can be followed from day to day both in the appearance of the arm the firming of the fragments the development of callus and the increase of the range of joint movement At the end of two weeks the fragments are glued together and the circular body bandage can be discontinued Callus formation is usually well vanced by the end of four weeks and demonstrable by roentgen ra Clinically sound union is present at the end of five to six weeks an at this time the matter of administering further treatment may be delegated to a technician. It should include radiant heat superficial massage and effleurage and active and assisted exercises for all the joints of the upper extremity Occasionally the development of bony union may require a little longer time than the period stated but this is rare and the gratifying thing about this method of treatment is the

the beginning When this plan is adopted the arm should be suspended from an overhead frame with the patient recumbent by means of adhesive traction to the forearm and with the elbow in right-angle flexion for the first week or two This method relieves pain helps to overcome swelling and permits a certain amount of active flexion and extension of the elbow Massage and passive mobilization should be administered daily the traction being released temporarily for this purpose At the end of two weeks the traction is discontinued, a bandage applied to the elbow and the patient allowed to be up with the arm in a sling Treatments should be given on alternate days with massage passive, active and assisted movements Passive and active exercises should be performed daily by the patient with the assistance of the uninjured hand. Active use for light tasks should be permitted at the end of four weeks the sling may be discarded at the end of six weeks and full activity encouraged I have seen some remarkable results achieved by this method in what were regarded as almost hopeless fractures It seems as if some credence must be given to the theory that early mobilization clears obstructing fragments from the path of the olecranon and coronoid processes and permits obtaining a range of function that would not be possible otherwise

Fractures of the Shaft of the Humerus.—Fractures of the shaft of the humerus lend themselves remarkably well to treatment by the method of early massage and mobilization For a time after the Great War it was considered necessary to employ traction to secure reduction of these fractures and it was only in the course of time that it became evident that even a slight amount of continuous traction might lead to distraction of the fragments and that this was a frequent forerunner of delayed union or nonunion The alternative method of reducing the fracture by manipulation and retaining correction by the application of a plaster spica jacket is cumbersome and uncomfortable for the patient and all too often uncertain in that reduction is frequently lost during the process of applying the plaster The old fashioned but time-honored method of splinting consisting of long coaptation splints preferably of molded plaster of paris extending from elbow to shoulder with a bandage to the forearm to control swelling and a narrow cravat sling to support the wrist supplemented during the first week or two by a circular body bandage holding the arm to the chest, seems to me equally effective in maintaining alignment and has the additional great advantage of being easily removable and thus facilitating treatment by massage and mobilization For it seems clear to me from actual experience that Lucas-Championnière s methods when properly applied are capable of overcoming muscle spasm and thus improving the alignment of fractures of the shaft of the humerus and of likewise improving the circulation of the arm so that union is hastened and earlier functional recovery obtained.

When the fracture is of the transverse type there may be some

advantage in attempting manipulative reduction with the aid of an anesthetic in the hope of being able to enmesh or to interlock the frag ments When successful the after treatment is simplified when un successful, nothing has been lost. When the fracture is either of the oblique or comminuted type, manipulative reduction is foredoomed to failure and ought not to be attempted In these cases light superficial massage should be administered to relax the muscles and then without any anesthesia the angular deformity should be gently corrected and the coaptation splints and the dressings applied As a rule, no great difficulty is experienced in controlling the alignment in this manner and as the spasm of the muscles is overcome by daily massage treat ments, the reduction becomes more and more perfect, the weight of the unsupported elbow providing a certain traction force If any diffi culty is experienced in obtaining reduction particularly in the oblique or transverse fractures it is usually because tissue has been interposed between the fragments and this is an indication for operative reduc tion usually with internal fixation of the fragments by one or another method. Following operation rigid splinting should be employed for the first two weeks, but after this massage and mobilization may be begun

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rapidity of healing in contrast to the slow healing with other methods. The surgeon should be on the alert, however, to detect any evidence of tissue interposition between the fragments and to subject patients with this complication to operative reduction during the first 14 to 20 days

Radial nerve injury, which is a relatively common complication of fracture of the shaft of the humerus, necessitates no particular change in the program of treatment. It is important to differentiate between a primary nerve injury, which is usually due to contusion or stretching of the nerve and therefore recovers promptly, and a secondary lesion, which is apt to be due to the nerve being caught between the fragments or to constriction by callus and hence requires surgical exploration In all cases of radial nerve injury stretching of the paralyzed extensor muscles should be prevented by supporting the fingers and wrist in the position of hyperextension on a long cock up splint. This should be removed during the treatments for mobilization of the various joints.

Fractures of the Upper End of the Humerus.—Fractures of the upper end of the humerus include a variety of bony injuries such as fracture of the anatomic neck fracture of the surgical neck, separation of the upper humeral epiphysis and fractures of the greater and lesser tuberosities. In addition any of these injuries may be complicated by dislocation of the shoulder A classification based upon anatomic situation is confusing however and of little practical value, as the majority of the fractures are extensively comminuted and involve more than one region. Fractures of the anatomic and surgical necks and of the greater tuberosity are frequently present in combination in the same individual. From the practical standpoint it is more helpful to classify these injuries on the basis of the presence or absence of bony deformity as this has a direct bearing on the treatment Also there seems to be some degree of relationship between the amount of deformity and the type of fracture displacement of the grosser sort being generally associated with the transverse fractures of the surgical neck, while slight or no displacement is more characteristic of the extensively comminuted fractures The fracture-dislocations must also be considered in a separate group

Fractures Associated with Little or No Displacement —The large majority of the fractures with little or no displacement are made up of the comminuted fractures so commonly encountered in elderly individuals and especially women This type of injury far outnumbers any other injury of the upper end of the humerus, and this together with its unfavorable age incidence accounts for its importance. The amount of comminution varies but there is generally a giving way of a considerable part of the cancellous structure with involvement of both the surgical and anatomic necks and fracture of the greater tuberosity as well. Disalignment is variable and generally slight or

absent, but there are exceptions in which the shaft is displaced medially or laterally with overriding

The treatment of these fractures has undergone an evolution since the Great War At first with the lessons of the conflict in mind it was considered necessary to splint the shoulder in a position of abduction, and this was accomplished either by the use of a Thomas splint or a so-called airplane splint. Continuous traction was usually employed in conjunction with the splint, and this was obtained by the application of adhesive plaster to the skin.

These methods either confined the patient to bed or necessitated the use of an encumbering appliance for several weeks and often resulted in obstinate stiffness of the shoulder as a result of the long fixation After trial of this method for several years it began to be realized that the results were no better if as good as those obtained formerly by other methods and that it was unnecessary to subject the patient to this ordeal. For the last five years we have discarded these methods and adopted instead the plan of treatment by early massage and mobilization The arm is fixed to the chest by a sling and circular bandage and no other apparatus is used Hospitalization of the patient is advisable for a period of at least two weeks Roberts [29] studied the results and these showed that complete recovery of function was obtained in almost all cases and in a much shorter time than when the shoulder had been fixed in abduction. In addition, this method of treatment has proved far more comfortable than the old and has avoided the necessity of recumbent treatment in the dorsal decubitus which is often unsafe in these elderly patients because of the danger of hypostatic congestion of the lungs

Massage of the light stroking type is administered when the patient is first seen. The treatment is given with both the patient and the physician seated the patient s forearm and elbow being supported on a pillow placed across his knee The entire shoulder and upper arm are treated When relaxation is obtained gentle passive motions of the shoulder are made in abduction and adduction flexion (forward elevation) and extension No rotary motions of the shoulder are attempted until the fragments have become glued together usually at the end of two weeks The treatments are best given every day for the first two weeks At the end of one week a considerable range of motion is possible without pain and pendulum movements of the shoulder may be started. These are performed with the patient standing and bending forward at the hips the arm hanging free from the shoulder like a pendulum. In this posture the shoulder may be quite easily made to assume a position of 70 degrees forward elevation whereas in any other posture it would be impossible to elevate the shoulder to this degree without pain. Gravity acting in the long axis of the arm, exerts a traction effect upon the region of the fracture and thus protects it. Active swinging movements of both shoulders are now made by the patient in the anteroposterior plane (flexion and extension) then in

the lateral plane (abduction and adduction), and finally in a circular plane (circumduction) These exercises are repeated twice a day by the patient, and the number and extent of the movements are gradually increased Massage and passive movements are continued daily or on alternate days

At the end of two weeks the circular bandage holding the arm to the chest may be discontinued and the arm supported only by a sling. The patient is encouraged to use the hand for such light tasks as are possible with the arm at the side. The treatments by massage and passive motion may be decreased to three times a week, but the pendulum exercises performed by the patient are continued twice daily Passive movements of the shoulder in rotation may also be started At the end of three weeks the sensitiveness has generally disappeared and only the stiffness remains The fragments are firmly cemented by soft callus Radiant heat treatment of the shoulder may now be given preliminary to the massage and passive mobilization, and also free movements of the shoulder in abduction and adduction with the patient recumbent may be added

At the end of four weeks a greater range of active use is possible, and the arm may be left out of the sling part time Anything that may be done without pain is permissible At this time the recumbent exercises of the shoulder are increased by the addition of forward elevation and of rotation with the shoulder abducted At the end of five weeks active voluntary exercises with the patient standing erect may be begun. Weakness of the deltoid, infraspinatus and supraspinatus muscles and stiffness in abduction and rotation persist for some time, and these movements may be aided by wall-climbing with the fingers and by a certain amount of assistance from the technician. Care is always employed to avoid pain. At the end of six to eight weeks from the time of injury progress may be aided by the use of simple types of apparatus. A stick or wand four feet in length may be used the patient grasps the ends in his hands with his arms by his side, and then swings the arms back and forth in the lateral plane the normal arm being used to push the injured shoulder into abduction. The patient next swings the arms forward and backward in the anteroposterior plane elevating the shoulder lifting the wand over the top of the head and dropping it down behind the neck, thus assisting in external rotation as well as in flexion and extension The patient then passes the wand behind his waist, grasps its ends and moves it from side to side in the lateral plane thus performing movements of abduction and adduction with the shoulders inwardly rotated.

From the end of the sixth week, active use should be encouraged in every way especially for aid in personal care and dressing Brushing the hair shaving and performing other acts in connection with the toilet are important because they are frequently repeated and require dexterity Swimming and practicing strokes in golf or tennis are to be encouraged for the younger patients dusting sweeping, and driv-

ing an automobile for the older ones. These help to recover the last few degrees of motion but the normal uses of the arm with the shoulder abducted or elevated are extremely few hence emphasis must be continually laid upon the necessity of keeping up active exercises until complete functional recovery is obtained Normal use of the shoulder is generally obtained in from eight to twelve weeks

Fractures Accompanied by Displacement —Many of the fractures of the upper end of the humerus are accompanied by gross displacement of the fragments. These are usually the transverse fractures of the surgical neck or fractures involving the epiphysial line. The head or proximal fragment is generally rotated into the position of abduction while the distal or shaft fragment is separated from the head and displaced sometimes laterally but usually medially into the axilla with gross overriding The brachial nerves or vessels may be injured Some of the comminuted fractures are likewise accompanied by displacement but unless the shaft is actually separated from the head we believe that better results will be obtained from treatment by massage and mobilization as outlined above without any attempt at reduction rather than by treating them with the aim of correcting all deformity

Reduction of the deformity should be attempted as soon as possible after injury by closed methods and when seen early satisfactory replacement can usually be obtained. We believe from our own experience that reduction is rarely accomplished by continuous traction after the manipulative method has failed and that in that case it is preferable to proceed forthwith to open operative reduction

Reduction is usually best maintained by constant traction with the shoulder abducted. Adhesive strips are fixed to the upper arm a Thomas splint is applied and the strips connected to a traction weight of five to eight pounds The splint should be suspended from an overhead frame, to facilitate change of position in bed by the patient. Whenever possible the elbow should be fixed in right angle flexion, as function is recovered much more quickly than when it has been fixed in extension. An alternative method of splinting is that described by Blake consisting of traction and suspension, with the shoulder abducted to the desired degree Fixation by one or the other types of apparatus must usually be continued for a period of about three weeks at the end of which time the arm can be brought down to the side without danger of recurrent displacement. When for any reason the patient must be made ambulatory at an earlier period it is necessary to apply an airplane splint to maintain abduction.

Since many of the displaced fractures occur in patients of youthful or early adult age there is less danger of stiffness as a result of immobilization of the shoulder than in the elderly patients with the comminuted fractures and a good anatomic result should be sought as the best foundation for good function As long as the shoulder and arm are fixed by apparatus physical therapy cannot be employed. The

traction and suspension method of treatment allows a certain amount of shoulder and elbow motion, however, which to a considerable degree offsets this loss When the apparatus is removed the patient is permitted to be up, carrying the arm in a sling, and at this time massage and mobilization treatments may be started The general program corresponds to that described previously for fractures without displacement, except for the difference that it is started two to three weeks later, and the progression depends upon the rapidity of the functional response instead of the speed of callus formation.

FRACTURE DISLOCATIONS —The occurrence of dislocation of the shoulder in combination with fracture of the upper end of the humerus adds a serious complication to the latter injury and unfavorably modifies its prognosis Fracture-dislocations in which the fracture involves the greater tuberosity are much more favorable than those in which the fracture involves the surgical neck however, and it is important for purposes of treatment to differentiate between them.

Dislocations with Fracture of the Greater Tuberosity—Fracture of the greater tuberosity is a frequent accompaniment of dislocation of the shoulder the bony prominence being retained in position by its muscular attachments and left behind as the head displaces from the glenoid This injury should be treated by immediate closed reduction and replacement can usually be accomplished by either Kocher's or the traction method Reduction of the dislocation also brings about reposition of the fracture with such secure apposition of the fragments that after immobilization for the period of one week the danger of redisplacement may be disregarded and the shoulder treated by massage and mobilization. Fixation is secured by sling and circular bandage with the arm by the side The program of physical treatment corresponds in all respects to that outlined for fractures of the upper end of the humerus without displacement. With coöperation on the part of the patient complete recovery of function can usually be expected in from eight to twelve weeks

Dislocations with Fracture of the Neck of the Humerus—Fracture dislocations of the shoulder in which the surgical or anatomic neck of the humerus is fractured represent a much more difficult problem Reduction of the dislocation should be attempted by the traction method aided by pressure on the head by the operator's fist in the axilla Complete replacement is obtained in a certain number of cases but more often the shaft separates from the head and is replaced in the glenoid cavity leaving the head behind When this occurs operative reduction is indicated but this raises the question of whether the head which has been cut off from all blood supply should be preserved and replaced in the glenoid or should be removed. Either policy is likely to prove unsatisfactory as far as functional recovery is concerned and considerable restriction of motion in abduction and rotation is to be expected On the basis of our own experience, we are

inclined to favor replacement of the head whenever possible as the better policy

Irrespective of whether the head is replaced or removed the after treatment necessitates fixation of the shoulder in a position of abduction for a considerable period and this is usually accomplished by Blake's method of traction and suspension followed later by the use of an airplane splint In the cases where reduction of the head has been accomplished by the closed method, the period of splinting is usually about three weeks When the head has become separated from the shaft and has had to be replaced by open operation the period of fixation is necessarily longer in order to permit revascularization from the distal fragment to take place and union to become firm—generally from six to eight weeks. When the head has been excised the shoulder should be maintained in abduction by the method of traction and suspension for a period of about three weeks at the end of which time massage and mobilization may be begun.

Physical therapy can be begun only after the removal of all apparatus and follows in a general way the program previously outlined for fractures of the upper end of the humerus without displacement. Since the treatment is begun later the response will be retarded and the program must be guided chiefly by the progress of the patient and *accelerated only as rapidly as the gain in movement justifies* Pain is the warning signal and indicates when the treatment is being pushed too rapidly Avoidance of pain should be the guiding principle

Fractures of the Shoulder Girdle.—Fractures of the Clavicle —Fracture of the clavicle is a common but generally benign injury It is encountered with the greatest frequency among children, the age period in which following injury function is recovered rapidly Except in the rare instances of fracture of the extreme outer tip of the clavicle the injury does not implicate any joint In addition the function of the clavicle is a simple one merely that of providing a strut to hold the shoulder outward and backward a function that is restored by the consolidation of the fracture even with deformity For these reasons fracture of the clavicle is rarely followed by any permanent disability

The most common site of fracture is the middle third Complete fractures in this region are generally accompanied by considerable deformity the outer fragment being displaced forward inward and downward with overriding Reduction is readily accomplished by drawing the shoulder upward outward and backward and retaining it in that position. The old Sayre and Velpeau dressings proved unsatisfactory in retaining reduction and had the additional disadvantage of immobilizing the shoulder They have now been superseded by a variety of apparatus each of which seems to maintain the fragments in satisfactory position while leaving the shoulder joint free From our own experience we recommend the figure-of 8 plaster bandage to both shoulders or some form of the clavicular T splint When properly

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applied, either of these dressings maintains reduction and yet permits maximum freedom of the shoulders In the case of women desirous of avoiding all possibility of a visible prominence at the site of the fracture recumbent treatment may be advised for a period of two to three weeks with the shoulder fixed in wide abduction by Blake's method of traction and suspension Nonunion is an occasional complication of fracture of the clavicle but is almost always the result of interposition of tissue and failure to obtain reduction.

With either the figure-of 8 plaster bandage or the clavicular T splint, a sling is worn for the first three or four days to support the arm, but thereafter is removed and active use of the arm and shoulder permitted. Since the shoulder is not immobilized, function is maintained and there is no need for physical therapy Active exercises to strengthen the muscles controlling the shoulder, upper arm and shoulder girdle may be prescribed with benefit in the convalescent stage after the splinting has been discontinued.

Fractures of the Scapula.—Fractures involving the body of the scapula are usually of the comminuted type and are associated with considerable damage to the muscles covering the scapula, namely, the supraspinatus infraspinatus, subscapularis teres major and minor, and the rhomboid muscles The effects of the injury are also likely to extend to the subscapular bursa with resulting adhesions and interference with rotation of the scapula upon the chest wall Displacement of the fragments is limited by their muscular attachments, and the amount of bony deformity is rarely sufficient to cause limitation of function. Even with extreme deformity, it is generally impossible to correct it because of the extreme comminution The treatment generally consists of fixation of the arm to the side by sling and circular body bandage

Physical therapy may be started at the end of one week in the form of light superficial massage and passive mobilization Massage should be administered with the patient seated to the region of the scapula, the lower neck shoulder and upper arm This should be followed by passive mobilization of the shoulder girdle and shoulder Treatment may be given daily during the second week, and thereafter on alternate days At the end of three weeks assisted movements may be started and active exercises may be prescribed at the end of four weeks. Applications of radiant heat may be given with benefit preceding the treatment from the end of the third week.

Recovery of function is often slow following fracture of the scapula, due to the extensive fibrotic changes in the scapular muscles and may require three to four months Exercises should be continued throughout this period and the use of apparatus is often beneficial such as wand exercises work with the weight and pulley golf practice, etc.

FRACTURES OF THE LOWER EXTREMITY

The functions of the lower extremity are of a highly specialized type and have to do chiefly with weight bearing and locomotion Weight bearing necessitates the ability to support for long periods of time the constant thrust of the body weight and also of whatever additional burdens are carried by the arms back or shoulders When the body is in locomotion this weight is shifted from one leg to the other and in reality sustained by one leg at a time The functional demands upon the skeletal apparatus of the legs are therefore quite different from those made upon the arms the former involving heavy and sustained duty and above all the ability to withstand end-thrust. The legs are able to support this load because their structure is admirably adapted to that end The axes of the bones of the legs stand in nearly perpendicular relationship to the joint surfaces The broad articular surfaces of the knee and ankle lie in the horizontal plane and are parallel to each other The thrust is evenly distributed and is transmitted from one segment to the other with minimal strain upon the ligaments In addition the arched arrangement of the foot provides a tripod type of spring support which serves to cushion the weight impact with each step

The structural relationships are so completely harmonious that any alteration produced by a skeletal fracture is likely to be attended by serious consequences Angular deformity of the femur or tibia changes the weight distribution at the proximal and distal articulations so that one or more of the ligaments become strained resulting sooner or later in painful function. There is uneven bearing of the joint surfaces with excessive wear at certain parts leading to degeneration of the cartilage proliferative changes at the joint margins and finally resulting in the characteristic picture of a localized hypertrophic or traumatic arthritis Simple lateral displacement, provided that the axes of the fragments retain their perpendicular relationship to the joint surfaces is much less disabling even when accompanied by a little shortening because it does not alter the direction of the weight thrust. Shortening is unesthetic and can be avoided but as long as this does not exceed one inch it can be readily corrected by the addition of a small lift to the shoe which results in little functional impairment even for heavy work.

The locomotor function requires only a moderate amount of movement of the ankle, knee and hip In ordinary walking the knee is rarely flexed more than 45 degrees and the arc of ankle motion rarely exceeds 10 to 15 degrees A greater range of motion is necessary for running and for ascending or descending stairs Stooping kneeling and sitting call forth a still larger amount of motion in certain joints but except for the purpose of athletic competitions the full range of possible joint movement is seldom utilized The ordinary individual can therefore tolerate a certain degree of limitation of the

movements of the hip, knee or ankle with little functional loss, and even complete ankylosis of one of these joints, provided that it is fixed in the position of optimum function, constitutes but a small handicap

The practical conclusion to be drawn from these observations is that in dealing with fractures of the lower extremity preservation of skeletal alignment is more important than restoration of complete mobility This does not mean to imply that one should not aim for full restoration of movement but that early mobilization of the articulations should never be prescribed if it involves the slightest risk of disturbing the alignment. Fractures of the shafts of the long bones of the leg require a considerably longer period for consolidation than those of the arm, and until the union is fairly firm there is always danger of displacement. For this reason it is rarely safe to treat such injuries by massage and mobilization until consolidation is well advanced. In respect to restoring function chief reliance must be placed upon such mobilization as may be obtained in conjunction with the traction-suspension method of treatment or upon the stimulation produced by the use of weight-bearing appliances In general, early massage and mobilization are of chief benefit in fractures involving the ankle and knee, but even here they must be employed only with certain safeguards and limitations. It therefore follows that the rôle of physical therapy in the treatment of fractures of the lower extremity is very different from that in the upper extremity Its use must frequently be delayed until the end-stage when it is of small value and in the interval substitutes must be employed While this is true in a general way we must not overlook the occasional instances in which early physical therapy can be employed with advantage Fixation of the fracture and immobilization of the joints can be just as much overdone in fractures involving the leg as in those of the arm. In applying physical therapy to the lower extremity attention must be paid to all the joints the foot and ankle must not be neglected when treating the knee nor should the knee be overlooked when treating the hip Also greater emphasis is to be placed upon active exercises performed regularly by the patient than upon massage or passive mobilization.

Fractures of the Foot.—The arches of the foot are flexible instead of rigid structures and depend for their support upon a balanced relationship between the strength of the different groups of muscles. Normally the inverting or supinating muscles are stronger than the everting or pronating muscles and tests of muscle strength show a ratio of 4 3 in favor of the former Weakening of the supinator muscles results in loss of support of the arch and pronation of the foot. Fractures of the bones of the foot disturb its function not only by alteration of its skeletal structure but also by the inevitable weakening of the muscles that results from immobilization or lack of use When

weight bearing is resumed the foot may pronate and in the absence of proper support ligamentous strain may result

It is therefore an important matter to guard against disabilities of the foot after any bony injury of the lower extremity Shoes of ample size and proper shape should be fitted In the beginning support of the arches may be necessary and may be provided by building up the inner side of the heel one-quarter inch or by fitting a padded leather insole or some other type of arch support. If there is flattening of the anterior arch, a leather metatarsal bar three-quarters of an inch wide and one-quarter inch thick may be nailed across the sole to relieve pressure upon the heads of the metatarsals or an anterior foot cuff of leather may be employed In addition special foot exercises should be prescribed to strengthen the supporting muscles the inverters and the toe flexors A satisfactory group of exercises is as follows

1 Standing with the feet bare rise slowly on the toes of both feet and down again (10 times)

2 Stand on small platform or a thick book with the toes projecting over the end Flex all of the toes downward strongly and return. (10 times)

3 Sitting cross one leg over the opposite knee and perform circular rotating movements with the foot Plantar flex the foot, rotate the toes inward (invert) dorsiflex the foot rotate the toes outward (evert) and plantar flex. (A completely circular movement should be made ten times with each foot)

4 Roll a small towel lengthways place it on the floor under the toes and curl the toes in plantar flexion over it trying to grip and squeeze it. An alternative form of this exercise is to pick up a marble from the floor grasping it with the flexed toes lifting the leg inverting the foot and dropping the marble in the hand of the opposite side (Each exercise should be performed ten times with each foot.)

Fractures of the Phalanges and Metatarsals —Fractures of a single phalanx or of one metatarsal represent simple problems and seldom result in disability Bony deformity is often lacking but when present should be corrected by the closed method and the part splinted with felt strips or a cardboard roll fixed with adhesive plaster and bandage Elevation is necessary to counteract swelling Physical therapy is not indicated in the treatment

Multiple fractures of the phalanges and metatarsals resulting from crushing injuries are unfortunately fairly common and present more difficult problems They are often compound and frequently necessitate the amputation of one or more toes because of circulatory impairment and gangrene There is often gross displacement of the bones. Such injuries require treatment by continuous traction obtained either by adhesive plaster fastened to the skin of the toes or by pins or wires

movements of the hip knee or ankle with little functional loss and even complete ankylosis of one of these joints provided that it is fixed in the position of optimum function, constitutes but a small handicap.

The practical conclusion to be drawn from these observations is that in dealing with fractures of the lower extremity, preservation of skeletal alignment is more important than restoration of complete mobility This does not mean to imply that one should not aim for full restoration of movement, but that early mobilization of the articulations should never be prescribed if it involves the slightest risk of disturbing the alignment Fractures of the shafts of the long bones of the leg require a considerably longer period for consolidation than those of the arm and until the union is fairly firm there is always danger of displacement. For this reason it is rarely safe to treat such injuries by massage and mobilization until consolidation is well advanced In respect to restoring function chief reliance must be placed upon such mobilization as may be obtained in conjunction with the traction-suspension method of treatment or upon the stimulation produced by the use of weight-bearing appliances. In general, early massage and mobilization are of chief benefit in fractures involving the ankle and knee but even here they must be employed only with certain safeguards and limitations. It therefore follows that the rôle of physical therapy in the treatment of fractures of the lower extremity is very different from that in the upper extremity Its use must frequently be delayed until the end-stage when it is of small value and in the interval substitutes must be employed While this is true in a general way we must not overlook the occasional instances in which early physical therapy can be employed with advantage Fixation of the fracture and immobilization of the joints can be just as much overdone in fractures involving the leg as in those of the arm In applying physical therapy to the lower extremity attention must be paid to all the joints the foot and ankle must not be neglected when treating the knee nor should the knee be overlooked when treating the hip Also greater emphasis is to be placed upon active exercises performed regularly by the patient than upon massage or passive mobilization.

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three to six weeks In addition, active exercises should be prescribed to mobilize the stiffened joints and develop muscular control and strength These should include exercises for the knee and hip as well as for the foot and ankle Progress is likely to be slow and depends a great deal upon the patient s ability to coöperate Recovery of function in a period of six months is to be considered as an excellent result

Fractures of the Ankle.—Fractures of the ankle present a wide variety of clinical types and occur in varying combinations of fracture of one or both malleoli or of the articular margins diastasis of the tibiofibular junction and displacement of the astragalus in the outward inward backward or upward directions. They may be accompanied by no bony deformity or by very gross deformity It is not within the scope of this article to discuss the classification of these injuries or to consider their surgical treatment in detail, but it is important to point out that an exact diagnosis not only in respect to the structures involved but also as to the mechanism by which the injury was produced is the necessary cornerstone on which to build a sound plan of treatment. We will limit our remarks to a consideration of how the treatment of ankle fractures may be aided by physical therapy To facilitate this purpose we will divide these injuries on the basis of the presence or absence of bone deformity

Fractures of the Ankle Without Displacement —Many of the fractures of the ankle are accompanied by slight or no bony displacement Such injuries are usually complete fractures but the fracturing force has stopped short of that necessary to rupture the ligaments and the astragalus has remained in the ankle mortise The most common injury in this group is the oblique fracture of the external malleolus resulting from external rotation of the foot

Many of these fractures have been overtreated and in certain instances have been kept continuously immobilized for periods of many weeks There is no necessity for prolonged fixation and this only leads to lengthening of the disability period. On the other hand it is not advisable to permit active use or direct weight bearing except in the very minor sprain fractures where small flakes of bone have been torn off by the ligaments. In such cases the ankle can be protected by an adhesive strapping and use permitted

For the most part however weight bearing would result in strain at the seat of fracture and would be productive of irritation and pain In some cases it might lead to actual displacement The fracture should be protected by the application of a plaster casing holding the foot in a neutral position and this should be split immediately to permit mobilizing treatment A steel stirrup (Böhler) can frequently be incorporated in the posterior half of the plaster and walking may be

passed through the phalanges. A plaster cast is applied from the toes to the knee with a wire hoop incorporated in the front portion, and to this the traction appliances are fixed by means of elastic rubber bands. Efforts should be made to mold the anterior arch and prevent the development of painful bony prominences on the plantar surface.

Physical therapy can rarely be employed before the end of two to three weeks and then consists chiefly of contrast baths to stimulate the circulation and active exercises to restore flexion and extension of the toes, and to develop the muscles supporting the arch. Weight bearing in a large shoe fitted when indicated with a support for the anterior arch, may be permitted at the end of four to five weeks. Massage may be of service in mobilizing adherent scars also in mobilizing the heads of the metatarsals and restoring the flexibility of the anterior arch.

Fractures of the Os Calcis and Other Tarsal Bones.—Fractures of the os calcis, astragalus or tarsal scaphoid bone are common and often permanently disabling injuries, those of the os calcis being particularly notorious for their crippling effect and having a frequency estimated as high as 2 per cent of all fractures. The treatment of each of these injuries is highly specialized and cannot be outlined in our limited space beyond emphasizing the importance of as early and complete correction of deformity as possible and of immobilization for the period necessary to obtain bony healing, usually a matter of eight weeks or more. Fixation is usually obtained by the application of a plaster casing, and because of the inadvisability of beginning physical therapy before consolidation of the fracture has occurred, it is of particular importance to make use of weight-bearing pads or stirrups in order to stimulate the circulation in some manner and to counteract bone atrophy. When the fracture involves the subastragalar or astragaloscaphoid articulations with irreparable damage to the function of these joints, an operation to ankylose one or the other of the joints may be indicated in order to get rid of a source of pain. In the case of fracture or dislocation of the astragalus, often compound, the operation of astragalectomy may be necessary.

After the removal of the splints, weight bearing is permitted in a large easy shoe at first with the aid of crutches. In the case of fractures of the os calcis it may be advisable to apply an outside jointed brace fixed to the shoe, for the purpose of limiting lateral mobility of the foot for a short period. If there is a tendency toward pronation of the foot, it should be prevented by the use of a Thomas heel elevated one-quarter inch on the inner side. In the beginning there is apt to be obstinate swelling of the foot, and this should be counteracted by frequent elevation of the leg, contrast bathing of the foot twice daily and the use of a woven elastic bandage. Treatment by radiant heat and massage at two-day intervals is of benefit in restoring the circulation and overcoming swelling but should not be continued for more than

patient ten to fifteen times twice daily and during the intervals the plaster window should be replaced and fixed with straps

The second alternative is to adopt the method of Böhler and apply an unpadded plaster casing fitted with a steel stirrup for weight bearing This may be done either immediately after the reduction or only after the use of a padded casing for the first week or two for the sake of safety Walking in this plaster improves the circulation and contributes a good deal to the early restoration of function. In some instances both of these procedures may be combined

Generally the consolidation of the fracture is sufficiently advanced by the end of four weeks to permit the daily removal of the splints and treatment of the entire part by massage and mobilization The treatment should be given on an average of three times a week and should include both passive and assisted movements Active exercises may be prescribed at the end of six weeks preceded by contrast baths and the splints may be discontinued. Unprotected weight bearing should not be permitted before the end of eight weeks thereafter active use and exercises are all that are needed to restore function

Fractures of the Bones of the Leg.—FRACTURE OF THE FIBULA ALONE.—Fracture of the shaft of the fibula represents a minor type of injury and we have never seen it give rise to any permanent disability It only requires protective splinting for a week at most—the period during which unrestricted activity of the leg would be productive of pain The displacement is unimportant and does not necessitate any attempt at reduction It was in the treatment of this fracture that Lucas-Championnière made his trials of massage and mobilization with such brilliant results and it is likely that the best results even now will be obtained by following his methods Massage and mobilization may be administered from the beginning and after one week all splinting should be discontinued. Weight bearing may be permitted at the end of two to three weeks

FRACTURE OF THE TIBIA ALONE.—Fracture of the shaft of the tibia without accompanying fracture of the fibula is a much less severe injury than fracture of both bones of the leg The intact fibula limits the amount of displacement, and after reduction is accomplished becomes a sustaining factor in helping to maintain reduction. But the very reason that makes it helpful in these two instances renders it an obstacle that must be overcome in securing reduction of a displaced fracture since it prevents the effective use of traction in restoring alignment. When reduction is indicated it can usually be accomplished by the closed manipulative method but occasionally direct skeletal traction to the tibia or open reduction may be required The alignment is usually maintained by the application of a plaster casing extending from the toes to the upper thigh.

permitted with this support when the two halves of the plaster are strapped together

The most important part of the treatment, however is massage and mobilization This should begin immediately after injury and should be continued on alternate days thereafter The massage should be of the light stroking variety and administered not only to the region of the ankle but to the foot and leg as well It should be followed by gentle passive mobilization and after the end of the first week assisted motion may be given Active unassisted exercises may be started at the end of two weeks and should be performed at home twice daily preceded by contrast bathing Generally there is no need of any splinting protection after the end of three to four weeks but active unprotected weight bearing should not be permitted until the end of six weeks

FRACTURES OF THE ANKLE WITH DISPLACEMENT —In treating fractures of the ankle with displacement the predominant requirement is careful reduction of the fracture with complete correction of the deformity It may be positively stated that without complete reduction the function of the ankle will never be satisfactory Reduction is to be sought as early as possible after injury, and can usually be accomplished by traction and manipulation with the patient anesthetized. Reduction is best maintained by the application of plaster-of-paris splints or casings The foot should be fixed generally in the inverted position (in the case of fractures by adduction or tibial flexion in the position of eversion) and with the ankle in extreme dorsiflexion. The latter is of extreme functional importance for dorsiflexion is recovered with great difficulty particularly in the posterior marginal fractures and unless the ankle is brought up into the position of right angle flexion or preferably above there will always be a slight permanent equinus and this restriction of motion is likely to be accompanied by some pain and disability on use

The reduction of a previously displaced fracture of the ankle may readily be lost if the position of the foot is changed therefore it is highly dangerous to lift the ankle from the splints to permit early treatment by physical therapy Under these circumstances one must resort to either one or another of two substitute procedures if any attempt is to be made to counteract the effects of continuous immobilization. The first is to cut out the anterior half of the plaster over the dorsum of the foot and ankle but leaving the posterior shell intact to hold the foot in the corrected position This provides the opportunity for active movement of the foot in the directions of dorsiflexion and inversion movements that do not endanger the reduction. The possible range of motion is small but even a little movement is sufficient to activate the circulation overcome swelling restore joint flexibility and keep up muscle tone. The movements should be performed by the

deformity and permit active weight bearing. Physical therapy consisting of radiant heat deep stroking massage and mobilization of both the passive and assisted types will prove beneficial at this time They should rarely be continued for more than six weeks after this time progress is to be obtained chiefly by use and active exercises

Injuries in the Region of the Knee.—The quadriceps extensor muscle plays an important part in maintaining function of the knee joint through the attachment of its crureus portion to the superior prolongation of the joint capsule The muscle has the duty of maintaining tension on the capsule and of preventing the development of relaxation folds which might interfere mechanically with joint movement. From the physiologic point of view a healthy quadriceps muscle is a necessity for normal knee joint function. Following any injury to the knee joint especially when immobilization is employed there occurs a rapid and marked wasting of the quadriceps muscle. Even though healing of the injured structure is obtained impairment of knee joint function will persist until the normal power of the quadriceps is regained Treatment to develop the quadriceps is of the greatest importance after any injury of the knee joint and should be continued as long as atrophy of the thigh can be demonstrated by measurement. It should begin at the earliest possible moment with quadriceps setting exercises performed 100 to 200 times a day As soon as movement can be permitted these should be supplemented by assisted and active motions of flexion and extension In the convalescent stage exercises against resistance should be prescribed including extension of the knee against gravity push up exercises with the knees from the squatting position, extension against the resistance of the weight and pulley and finally active work with the rowing machine

Another feature to be guarded against in the treatment of injuries in or about the knee joint is stretching of the capsule from the distention of effusions whether serous or sanguineous Such stretching causes capsular relaxation and may be a factor in delaying recovery after healing of the injury has been obtained. It is more likely to occur in cases of chronic effusion For this reason it is important to relieve and prevent distention by aspiration, repeated if necessary whenever joint effusion is a feature of injury Absorption of fluid from the knee joint is also hastened by massage and mobilization (Bauer [26]) In the treatment of knee-joint injuries one should apply when possible the principles of relief of effusion by aspiration and early mobilization as the best means of conserving function

Fractures of the Tibial Tuberosities.—Fractures of the upper end of the tibia extending into the knee joint have become very common owing to the prevalent height of automobile bumpers They most frequently implicate the lateral tuberosity and may be accompanied by fractures of the upper end of the fibula or of the shaft of

The indications for physical therapy in fractures of the tibia alone are variable and depend altogether upon the amount of displacement and the security of the reduction In fractures without displacement, massage and mobilization may be administered from the beginning in the others, it usually has to be postponed until the end of about four weeks when the consolidation is generally far enough advanced to permit handling the limb in safety In the interim the weight-bearing plaster fitted with a steel walking stirrup may frequently be employed

Radiant heat massage passive and active mobilization will be required for a period of about four weeks after the removal of the plaster, to stimulate the circulation and activate the muscles and joints Active weight bearing without protection may usually be permitted at the end of eight weeks following which there is little need for other physical therapy than active exercises to restore strength.

Fractures of Both Bones of the Legs —The treatment of fractures of both bones of the leg often represents a difficult problem. Frequently compound often comminuted and grossly displaced and exhibiting a marked tendency to delayed union or nonunion, chief emphasis in the treatment of these fractures must be placed upon prevention of infection safeguarding the soft parts from additional damage restoration of normal alignment and obtaining bony union. Physical therapy must be relegated to a minor *rôle* until the apparatus can be removed with safety Certain of these fractures can be treated successfully by the method of closed reduction and plaster fixation but the number is small In the comminuted and oblique fractures alignment can be restored and maintained only by the use of direct skeletal traction with a pin or wire through the heel or lower end of the tibia, the extremity being suspended in a Thomas splint. The transverse and spiral fractures are often best treated by open reduction with fixation of the fragments by screws plates or bands

With reduction so difficult to obtain and maintenance of alignment so precarious it is inadvisable to attempt early massage and mobilization For functional stimulation of the extremity reliance must be placed upon the use of traction and suspension instead of complete fixation and the opportunity this affords for limited mobilization of the articulations One must also be quick to employ weight-bearing appliances such as caliper braces and walking plasters Consolidation may require a period of from eight to sixteen weeks or even longer and it is only when the union is solid that massage and movement may be started As a rule when union is not solid by the end of eight weeks a caliper brace carefully fitted with a leather cuff supporting the region of fracture should be applied Use is the best means of stimulating the circulation and of promoting union and such a brace will protect even a mobile fracture sufficiently to prevent

stroking massage and relaxed motion Following reduction the splinted extremity should be suspended in slings from an overhead frame to secure the advantages of elevation. If necessary the plaster cast can be split the anterior half removed and the leg exposed to continuous radiant heat

Although in the treatment of fractures with displacement physical therapy may be started at the end of three to four weeks splinting should be continued until six to eight weeks after injury to guard against recurrence of the deformity In the interval treatment by radiant heat massage relaxed and assisted motion should be continued systematically the hands of the technician being used to support the leg during the movements in a manner to prevent any strain at the seat of injury After fixation of the extremity is no longer necessary the patient should be allowed to begin to get about with the aid of the caliper brace At this time chief emphasis should be placed upon active and resisted exercises but massage and passive movement should be continued as long as swelling of the knee persists and knee function remains impaired—usually not longer than four months from the time of injury

In the case of fractures that are treated in suspension and traction with early movement, massage of the knee and thigh may be administered from the start and should usually be continued on alternate days until the apparatus is removed. Mobilization should be done by the patient, but the surgeon should supervise this closely to be sure that the exercises are being performed regularly and that the range of knee motion is improving As a rule no difficulty is experienced the patient quickly gaining confidence and making rapid progress The leg is left suspended in the splint for a period of four to eight weeks depending upon the type of fracture and the degree of comminution After the removal of the apparatus the treatment is the same as that described above for fractures with displacement.

Fractures of the Femoral Condyles —Fractures of the condyles of the femur may be divided into two groups The first group is made up of fractures of small fragments of bone evulsed from the medial surface of the internal condyle or the lateral surface of the external condyle by the pull of one of the lateral ligaments of the knee joint. The second group is composed of the severe intercondylar fractures associated with transverse fracture of the shaft of the femur in the lower third

The first group represents fairly insignificant injuries and with proper treatment almost never results in any disability The fracture is in reality a variant of rupture of one of the lateral ligaments and the treatment should be modeled along the same line. A plaster casing extending from the ankle to the groin should be applied with the knee in a position of about 30 degrees flexion in order to secure relaxation of the ligament The displacement is generally slight and

the tibia the latter feature complicating the treatment considerably The bony displacement usually takes the form of a depression of the lateral tuberosity, with broadening of the upper end of the tibia and the production of knock knee deformity The amount of displacement is variable When the deformity is marked, it should be corrected by closed manipulation or occasionally by operation and the reduced position maintained by the application of a plaster casing When the amount of deformity is slight or when owing to comminution it is of a type impossible to correct protection and early motion constitute the chief indications These may be met by suspension of the leg in a Thomas splint fitted with a hinged knee attachment adhesive traction of the integral type being attached to the lower leg A cord may be run from the end of the movable leg-piece over pulleys fixed to the overhead frame until the end is within convenient reach of the patient s hand By pulling on this cord the patient may extend or flex his knee and thus the opportunity is provided for regular and systematic mobilization of the passive and assisted type

One of the chief difficulties resulting from this type of fracture is lateral instability of the knee joint This is caused by injury and relaxation of the internal lateral ligament of the knee joint coupled with widening of the joint interspace at the outer side of the knee, resulting from failure to correct the depression of the lateral tuberosity This not infrequently causes persistent weakness and pain in the knee joint when active use of the extremity is resumed. To prevent this disability, emphasis should be placed in the early stage upon as complete reduction as possible of the deformity with elevation of the depressed tuberosity In the later convalescent stage, upon prolonged protection of the injured lateral ligament by the use of a brace In addition there is need for prolonged protection of the seat of fracture as the spongy bone of the tuberosity remains soft for a long time after the fracture has healed and may crumple down under the weight of the body For these several reasons a caliper brace should be fitted before the patient is allowed to be up and should be worn regularly until four to six months after injury It should be equipped with a lock knee joint to permit flexion of the knee when sitting.

Physical therapy is a very important aid in the treatment of fractures of the tibial tuberosities In the fractures with deformity requiring reduction fixation of the knee joint must be enforced for a period of three to four weeks At the end of this time the cast should be split and the extremity lifted out every day for massage of the knee, thigh and leg and gentle passive mobilization Prolonged fixation is unwise and almost always results in considerable limitation of motion. These fractures are frequently accompanied by severe circulatory disturbance with marked swelling and extensive bleb formation Such cases should be treated prior to reduction by gentle

considered If manipulation is performed it should be done gently without any attempt to restore more than a partial range of motion otherwise it will be followed by an excessive inflammatory reaction in the tissues about the joint that will prevent progress Several partial manipulations at intervals of one month are better in restoring motion than one complete manipulation Care should be taken to protect the seat of fracture by firm support under the femoral condyles Treatment by physical therapy should be resumed beginning one to two days after the manipulation As quickly as the patient's condition warrants exercises on the rowing machine should be prescribed At the end of 14 weeks chief reliance should be placed upon active exercises and thereafter time and active use are the chief remedies

Fractures of the Patella.—The treatment of fractures of the patella varies depending upon the type of fracture and the amount of separation of the fragments

Fractures Without Displacement—The patella may be fractured without separation or with only slight displacement of the fragments The number of such injuries is small but nevertheless it represents a definite type. The fracture may consist of a transverse or vertical crack or it may be considerably comminuted The lateral expansions of the quadriceps are untorn and serve as ligaments to hold the fragments together Such fractures are usually best treated by the application of a plaster casing extending from the ankle to the groin or by a posterior splint with the knee in the position of full extension When a casing is used it should be immediately split and the halves retained in position by straps With such protection weight bearing may be permitted from the beginning Treatment by physical therapy should be started as soon as possible after injury the splints being removed every day or on alternate days for this purpose It should consist in the application of radiant heat, superficial massage and relaxed motion Active exercises may be started at the end of two weeks and unprotected weight bearing at the end of four weeks

Fractures with Separation—The most common type of injury of the patella is the transverse fracture located at the junction of the lower and middle thirds and accompanied by considerable separation of the fragments. There may be a greater or lesser degree of comminution, and the lateral expansions of the quadriceps are severely lacerated The best method of treatment of these fractures is by open operative repair of the torn ligaments with approximation and suture of the fragments Without operative treatment bony union cannot be obtained both by reason of the separation of the fragments and also because of the interposition of frayed out tendon fibers between the fractured surfaces. Preferably nonabsorbable suture material such as fascia lata or wire, should be used to fix the fragments

reduction is not required Weight bearing in the plaster cast may be permitted from the beginning, and no other physical therapy is needed until the splint is removed usually at the end of about six weeks At this time the use of radiant heat, massage, and active and resisted exercises should be begun and active use encouraged. As a rule there is no interruption to the rapid recovery of function.

The intercondylar T fractures of the femur are a very different class of injuries and include some of the most severe traumatisms that may be encountered They usually result from a fall on the flexed knee. The lower end of the shaft of the femur is fractured, the end of the proximal fragment is driven into the distal one splitting the condyles and not infrequently is pushed forward into the suprapatellar pouch and out through the quadriceps expansion, with the production of a compound wound involving the knee joint. There is extensive soft part damage and hemorrhage, the patient is in severe shock The most skillful surgical treatment is required if his life and limb are to be saved Under such circumstances physical therapy can have no part in the treatment until long after when the fate of the extremity has been decided and one may begin to think of restoring function. As a matter of fact knee stiffness of some degree is inevitable and will have to be accepted as the necessary consequence of the extensive soft part damage and scar tissue formation The only question will be concerning the amount of motion that can be saved

Intercondylar fractures of the femur are usually best treated by skeletal traction by means of a wire or pin passed through the upper end of the tibia at the level of the tubercle the limb being suspended in a Thomas splint, with the knee partially flexed Continuous heavy traction in the axis of the thigh usually brings about prompt realignment of the fragments with satisfactory restoration of the contour of the condyles Treatment in traction and suspension must be continued for a period of at least six weeks. During the period of treatment in apparatus it is impossible to do much toward restoring knee function although motion of the ankle and hip may be maintained A calliper brace fitted with a lock joint at the knee should be adjusted at the end of eight weeks and weight bearing permitted

Treatment by physical therapy can only be started when all apparatus has been removed usually at the end of six to eight weeks. It should be applied as intensively as possible during the first three or four weeks to make up for past neglect. It should include radiant heat light and deep massage to the calf and thigh, with special treatment of the scarred muscles, followed by passive, assisted and active motions of the knee Careful records should be kept showing the increase of motion. If at the end of three months no marked gain is noted the advisability of overcoming some of the adhesions by forcible passive flexion with the patient anesthetized, should be

considered. If manipulation is performed it should be done gently without any attempt to restore more than a partial range of motion otherwise it will be followed by an excessive inflammatory reaction in the tissues about the joint that will prevent progress Several partial manipulations at intervals of one month are better in restoring motion than one complete manipulation. Care should be taken to protect the seat of fracture by firm support under the femoral condyles Treatment by physical therapy should be resumed beginning one to two days after the manipulation As quickly as the patient s condition warrants exercises on the rowing machine should be prescribed. At the end of 14 weeks chief reliance should be placed upon active exercises and thereafter time and active use are the chief remedies

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in order to obviate the necessity of postoperative splinting With these materials the fragments can be fixed so securely that active mobilization can be permitted immediately after operation with considerable shortening of the disability period. When absorbable suture materials are used the mobilizing exercises cannot be pushed as rapidly and the recovery of motion is slower

Physical therapy is of great aid in the postoperative treatment of fractures of the patella. When osteosynthesis has been performed with fascia lata or wire the knee should be supported by soft dressings only During the first week no particular effort need be made toward mobilizing the knee as the patient will do this naturally as the acute operative reaction subsides and the soreness wears away As soon as the incision has healed, usually at the end of seven days superficial massage can be administered followed by passive lateral mobilization of the patella and relaxed movement of the knee. Active quadriceps setting exercises should also be prescribed The application of radiant heat can be added at the end of two weeks and daily active exercises of flexion and extension of the knee should be performed Active weight bearing can be permitted at the end of four weeks and thereafter recovery of strength and motion is chiefly dependent upon active exercises and use.

Fractures of the Shaft of the Femur —Fractures of the shaft of the femur are extremely severe injuries and in adults are frequently followed by some permanent impairment of function in spite of the very best treatment. In children below the age of fifteen years the results are much more favorable There is usually extensive injury of the soft parts even though the fracture escapes being made compound The reparative process leads to adhesion of the quadriceps extensor muscle to the callus so that the muscle becomes fixed and cannot extend with consequent restriction of the range of knee flexion. This is the common cause of the stiffness of the knee that is so frequently seen after fracture of the femoral shaft.

There is usually gross displacement of the fragments with marked overriding due to the shortening action of the powerful thigh muscles To overcome the displacement it is necessary to treat the fracture by continuous heavy traction and this is usually obtained by means of skeletal tongs applied just above the femoral condyles or by a pin or wire passed through the lower end of the femur The leg is usually suspended in a Thomas splint with the knee partially flexed on a hinged knee appliance fixed to the splint. The alternative method of treatment is by open operation with internal fixation of the fragments by a bone plate and screws or other fixative device. This method is applicable only in the transverse or oblique fractures not in the comminuted fractures Following operation the leg may be splinted in a Thomas splint with light traction or in a plaster-of paris spica casing Consolidation of the fracture proceeds slowly and

is rarely firm before the end of seven to eight weeks and may require considerably longer Until union is solid the leg must be kept splinted When weight bearing is begun protection must be provided in the form of a caliper brace. Active use of the leg is desirable at as early a moment as possible for its stimulating effects upon the formation of callus the circulation and muscles. The use of a caliper brace should be prescribed as a therapeutic procedure, usually at the end of eight to ten weeks

Physical therapy has to play a secondary rôle during the active phase of treatment of a fractured femur The necessity of securing anatomic reduction is predominant and without this only imperfect function can be expected The difficulties of securing reduction and the dangers of losing position are so great that it would not be justifiable to tamper with the apparatus for the sake of attempting early mobilization of the joints On the other hand with treatment by traction and suspension movement of the ankle and hip is permitted from the beginning and when traction is obtained by means of tongs or pins fixed directly to the lower end of the femur, it is possible to begin passive mobilization of the knee at the end of three to four weeks without danger of disturbing the alignment of the fracture In addition the use of skeletal traction has the advantage of leaving exposed for treatment by gentle massage a large part of the surface of the limb

For these various reasons the use of physical therapy in fractures of the femur depends chiefly upon the interest and attention of the surgeon in charge When the fracture is treated by skeletal traction with the leg suspended in a Thomas splint the administration of light superficial massage to the thigh and lower leg should be started at the end of two weeks. Regular active exercises of the ankle and foot may be started from the beginning After three to four weeks passive mobilization of the knee may be performed systematically each day within the limits permitted by the apparatus When the fracture has been treated by osteosynthesis by means of a bone plate and screws preference should be given to the use of traction and suspension in the after treatment instead of a plaster spica. From the standpoint of promoting the recovery of function the former method has great advantages and permits full benefit to be obtained from the firm operative fixation of the fracture. Massage of the thigh and lower leg and exercise of the ankle and knee may be administered from the end of two weeks Mobilization of the hip is obtained from the beginning by the changes in the position of the patient s body in bed Fixation of the leg in a plaster spica, on the other hand for the full period of eight weeks that is usually necessary is completely destructive of function and following the removal of the plaster a long and often painful course of mobilizing and stimulating treatment will be necessary to restore function

Following the removal of the retentive apparatus usually at the

end of about eight weeks, massage of the deep stroking type should be employed together with passive and assisted movement. Active exercises of flexion and extension of the knee should be prescribed and performed regularly at home by the patient A caliper brace fitted with a lock joint at the knee, to permit flexion of the knee when sitting should be adjusted With the protection of the brace, weight bearing on the leg may usually be allowed at the end of ten to twelve weeks This must usually be worn for a period of two to three months. During this time the patient should continue to work with the active exercises in order to increase the range of knee flexion, to mobilize the muscles and increase their strength These exercises should include lying on the face and flexing and extending the knee, sitting on the edge of a table and swinging the knee into full extension against the pull of gravity and dropping it again, and finally of standing holding on to the back of a chair with the hands squatting down on the heels and straightening up again. After the discontinuance of the caliper brace the exercises of the knee may be assisted with advantage by the use of apparatus such as the weight and pulley attached to the foot, the rowing machine or stationary bicycle. The range of knee motion increases slowly with active use over a long period and rarely reaches a complete standstill before the end of two years In the average case however with adequate early *functional* treatment, one may expect to obtain a range of knee motion of 90 degrees by the end of six months

Fractures of the Region of the Hip —INTERTROCHANTERIC FRACTURES OF THE FEMUR.—Fractures of the femur between the trochanters or along the intertrochanteric line are encountered most frequently in elderly people and more commonly in women than in men. The age factor complicates the treatment and makes it more difficult to secure complete restoration of function. The fracture itself is of a fairly benign character and because of its situation in cancellous bone where the blood supply is abundant, presents no problem in respect to obtaining bony union Bony deformity may be slight or well marked. It takes the form of a bending of the neck at its junction with the shaft, ascent of the greater trochanter and the production of distinct coxa vara. There is shortening of approximately one inch or more and some degree of permanent outward rotation of the leg as well

The deformity should be corrected and this can be readily accomplished by the application of continuous traction the leg being suspended in a Thomas splint Traction may be obtained by the application of adhesive plaster to the skin of the lower leg and thigh, but this involves fixation of the knee in the extended position for a period of approximately six weeks a period quite long enough in elderly persons to occasion stiffness of the knee that is difficult to overcome Such stiffness can be prevented by the use of skeletal

instead of adhesive traction The danger to the patient from the insertion of Kirschner's wire in the lower end of the femur is almost negligible and the advantage of skeletal traction in permitting regular mobilization of the knee joint is so great as to more than counterbalance the risk. A hinged knee appliance should be attached to the Thomas splint to support the lower leg and a cord should be rigged leading over pulleys to the end of the movable leg piece in such a way that the patient can extend or flex the knee by working the cord. Motion of the hip is obtained with the shifting of the position of the patient's body in bed, and the alignment of the fracture is not disturbed being maintained by the constant traction force In addition, the foot should be supported by a foot rest, or suspended from an overhead pulley by means of an adhesive strip to the plantar surface and a small weight. Thus nearly ideal conditions are produced for maintaining joint function during the period of treatment.

The chief obstacle to carrying out the ideal method of treatment of these fractures however is the feeble condition of many of the patients This makes it unsafe to employ a method that necessitates keeping the patient constantly in the dorsal recumbent position because of the danger of hypostatic pneumonia, bed sores and other difficulties. When these complications appear imminent, it is frequently the better policy to apply a plaster-of-paris spica casing fixing the hip in a position of wide abduction and maintaining traction by means of adhesive strips applied to the leg with the free ends fixed solidly in the plaster at the level of the ankle This method of splinting permits the patient to be turned face down as frequently as necessary to counterbalance any tendency toward hypostatic congestion of the lungs and to relieve pressure on the sacrum The fixation of the knee, however is likely to give rise to obstinate stiffness and this should be combated This may be done by employing the method described by Krida, which consists of the removal of the posterior half of the plaster from the knee to the toes as a lid The anterior portion of the leg-piece remains attached to the spica and maintains the position of the hip When the patient is turned face down, however the posterior plaster shell can be removed and this permits the knee to be flexed and extended and the ankle to be exercised This procedure can be used at the end of two weeks when it is no longer necessary to maintain traction and the strips can be freed

When the patient is treated by skeletal traction no formal treatment by physical therapy is indicated until after the removal of the apparatus but the surgeon should be careful to see that the patient mobilizes the knee and ankle regularly Union is usually solid in six to eight weeks and at this time the splints can be removed and treatment by massage passive and assisted movement begun The use of a calliper brace to protect the fracture and prevent shortening is often advisable and this should be worn for four to eight weeks During this period the use of radiant heat deep stroking massage passive and

end of about eight weeks massage of the deep stroking type should be employed together with passive and assisted movement. Active exercises of flexion and extension of the knee should be prescribed and performed regularly at home by the patient. A caliper brace fitted with a lock joint at the knee to permit flexion of the knee when sitting, should be adjusted With the protection of the brace, weight bearing on the leg may usually be allowed at the end of ten to twelve weeks This must usually be worn for a period of two to three months During this time the patient should continue to work with the active exercises in order to increase the range of knee flexion to mobilize the muscles and increase their strength These exercises should include lying on the face and flexing and extending the knee, sitting on the edge of a table and swinging the knee into full extension against the pull of gravity and dropping it again and finally of standing holding on to the back of a chair with the hands squatting down on the heels and straightening up again After the discontinuance of the caliper brace the exercises of the knee may be assisted with advantage by the use of apparatus such as the weight and pulley attached to the foot the rowing machine or stationary bicycle The range of knee motion increases slowly with active use over a long period and rarely reaches a complete standstill before the end of two years In the average case however with adequate early functional treatment one may expect to obtain a range of knee motion of 90 degrees by the end of six months

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the advanced age of many of the patients The shock of the injury the exhausting effect of pain or of the narcotics given to relieve it, the liability to hypostatic pneumonia and pressure sores added to their frequently debilitated state create a set of conditions from which a certain number succumb in spite of the best treatment

The method most widely advocated for securing reduction of the fracture is that originated by Whitman [31] This consists in manipulating both hips with the aid of traction into a position of wide abduction and internal rotation Anesthesia is generally necessary Following the manipulation the hip is fixed in the reduced position by the application of plaster of paris either in the form of a long single spica extending from the toes to the costal border or of a double spica extending on the injured side from the toes to above the pelvis and down the opposite side to the knee. The double spica secures more perfect fixation of the hip than the single spica and at the same time makes it possible for the patient to be turned more easily and to flex the spine more readily in sitting and for these reasons is to be preferred. It seems dangerous to apply plaster spicas to these elderly patients but it usually proves quite the contrary in practice The problems of handling the patient and of nursing care are greatly simplified The patient can be moved without pain turned regularly on the face and propped up in bed with the shoulders elevated This counteracts any tendency to the development of hypostatic pneumonia permits care of the back and prevents bed sores It may prove to be a life-saving procedure in many cases

Immobilization has to be maintained for a minimal period of twelve weeks on account of the slow process of healing Following the removal of the plaster a caliper brace to protect the fracture and at the same time permit weight bearing must be worn for a further period of three to six months End result studies show that even with this long period of treatment good results are achieved in only about sixty per cent of the cases It is doubtful whether actual bony union is obtained in as large a number as this These figures are disappointing and they are stimulating surgeons throughout the world to find improved methods of treatment. Open reduction is being tried among other experiments and the method originated by Smith Petersen [32] of employing a flanged nail to secure internal fixation of the fracture has yielded encouraging results It seems likely that the final word has not yet been said in respect to the best method of treatment of fractures of the neck of the femur Until this can be spoken however the Whitman method still remains the accepted standard and should be applied as literally as possible

Physical therapy cannot be employed in the treatment of fractures of the neck of the femur until at a late period because of the necessity of avoiding even the slightest motion at the hip Passive mobilization of the knee by the method of cutting out a posterior lid from the leg piece can be started at the end of six or eight weeks The knee should

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Fractures of the Neck of the Femur.—There is scarcely a more difficult problem in surgery than that of the treatment of fractures of the neck of the femur Although this injury is encountered chiefly in elderly women it is not confined to that group and examples of it may be seen in both sexes and at all ages from childhood up. There are many obstacles in the way of achieving good functional results One of the chief ones is the difficulty of obtaining bony union. In considering this question it is important to differentiate between the fractures through the narrow part of the neck or close to the head, the so-called intracapsular fractures and the fractures through the base of the neck the so-called extracapsular fractures The attempt to distinguish between these fractures on the basis of their situation in respect to the capsule is not accurate as injury implicates the joint in both types We prefer to use the more exact terms subcapital, transcervical and basal in describing the fractures

The importance of the anatomic situation of the fracture lies in its relation to the blood supply to the head of the femur In the transcervical or subcapital fractures the blood supply to the proximal fragment is likely to be completely interrupted except for that which is conveyed through the ligamentum teres In elderly persons the latter source is generally inadequate for nutritional needs and the head frequently dies In addition the neck of the femur is invested only with a covering of periosteum and synovial membrane, and enveloping soft parts from which granulation tissue may spring to aid in callus formation are lacking Consolidation must proceed entirely from the elements within the bone and often only from those in the distal fragments Under these conditions healing of the fracture is precarious and may fail entirely in many cases in spite of the best treatment The only chance of obtaining bony consolidation lies in obtaining complete reduction of the fracture with close approximation of the injured surfaces and in holding the fragments firmly fixed without any movement between them for a minimal period of three months On the other hand in the fractures at the base of the neck the conditions are much more favorable for healing. Parts or all of the capsular ligaments through which blood supply reaches the neck of the femur remain attached to the proximal fragment, and ample nutrition is assured In addition the adjacent soft tissues provide a source for extra osseous callus formation which may be of great aid in bringing about consolidation Clinical observation confirms these anatomic considerations and shows that union is obtained with great uniformity in the basal fractures and that they present no great problem from this standpoint.

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the ribs in the position of complete expiration, the shoulders droop forward and the abdominal wall is relaxed and paunchy This is a position of strain and the back tires more easily than normally Back ache may or may not become evident as long as the patient remains in normal health just as foot symptoms may be absent for long periods when the plantar arch is flat and the foot pronated The mechanics of the spine are bad but the individual is still able to com pensate and there is satisfactory function Compensation becomes increasingly difficult with the lapse of years and the reserve grows smaller The ability to compensate may be disturbed by an injury of the vertebral column or by weakening of the muscles from prolonged lack of use during the period of treatment. Recovery from the effects of the injury may be delayed by excessive strain thrown on the spine as a result of faulty attitude or the patient may complain of pain which he attributes to the injury when in reality it is caused by postural strain the injury itself having healed

The longer the body has been used in a position of faulty posture, the more difficult it is to secure correction The ligaments and muscles have adjusted themselves to the incorrect position and the deformity has become structural instead of remaining functional. Improvement of posture can still be obtained but only at the expense of considerable effort When function is resumed following recovery from a vertebral injury it is important that the spinal mechanics should be as favorable as possible and this condition can be realized only when all postural defects have been remedied It is therefore the part of wisdom to combine postural correction with the treatment of fractures of the spine whenever possible.

When fixation of the spine is indicated this is to be accomplished by the use of plaster shells or jackets which hold the spine as nearly as possible in the corrected position that is with the dorsal spine hyperextended the lumbar spine flattened and the pelvis tilted as little as possible. When spinal braces are used these should be fitted in such a way as to aid in postural correction When fixation is unnecessary and recumbent treatment suffices or in the convalescent period after the removal of retentive apparatus a definite régime of corrective positions and exercises should be prescribed Boards should be introduced between the springs and mattress to provide a firm flat bed The patient should be instructed to lie in the hyperextended position for a period of thirty minutes two or three times a day in order to stretch the contracted muscles and ligaments This is a position in which the patient lies on the back with a pillow placed transversely under the scapulae and upper dorsal region and with the shoulders abducted and the hands clasped behind the neck the knees being slightly flexed and supported by a pillow

The following exercises should be performed with the patient recumbent

be exercised regularly each day when the patient is turned on the face In spite of this maneuver, however, restoring function in the injured leg presents a problem when the plaster is finally removed. The venous and lymphatic circulation are incompetent, and the leg becomes greatly edematous the knee often showing the effects of previous arthritis is stiff and painful, the muscles of the thigh and leg are atrophied and weak and the function of the hip considerably impaired. Treatment by radiant heat to the knee, massage both superficial and deep of the leg and thigh, and passive and active mobilization of the ankle knee and hip should be administered on alternate days for a period of approximately one month after the removal of the retentive apparatus At the end of this time the patient ought to have progressed sufficiently with walking and active use of the leg to be able to continue to improve by means of his own efforts without additional treatment.

FRACTURES OF THE SPINE

Functional Considerations.—It is of *fundamental* importance in the treatment of all bony injuries *of the spine* regardless of their type to strive to obtain as *perfect weight bearing* alignment of the vertebral column as possible This refers not *only* to securing reduction of bony deformity at the seat of fracture when this is possible, but also to stretching the spinal ligaments and developing the supporting muscles so that the fully erect posture may be assumed and maintained The fully erect posture is to the spine what correct weight bearing lines are to the foot It is the position in which the weight thrust of the body is most easily supported, and in which the least *strain is* thrown upon the spinal ligaments and articulations. *In the fully erect* posture the normal anteroposterior curves of the spine are flattened the head is held erect in alignment with the body and with the chin pulled in the chest is elevated in a position of moderate inspiration the *abdominal* muscles are contracted *firmly* and the axis of the pelvis is only slightly tipped The *balance* of the body is easily maintained by the stay like *action of the* psoas, recti, intercostal and scaleni muscles in front *and by the* gluteal and sacrospinalis muscle groups behind. Lateral tilting is controlled and prevented by the action of the lateral oblique psoas and quadratus lumborum muscles.

Unfortunately partly as a result of the deforming pull of gravity and partly due to inattention on the part of the individual and lack of proper training the body is *rarely* held in a good mechanical position In fact poor posture is the rule. This is characterized by an exaggeration of the normal anteroposterior curves of the vertebral column with forward inclination of the *neck rounded kyphotic* deformity in the dorsal region marked lumbar lordosis and *marked* tilting of the pelvis The chin protrudes anteriorly the chest is flat with

5 Good standing position hands on hips pull abdomen in head up stretch body tall breathe deeply raising chest exhale by drawing abdomen in and up
6 Good standing position heels four inches from wall hips shoulders and head touching wall *flatten back by drawing abdomen in and up*
7 Good standing position feet apart, weight well forward and on outside of feet abdomen in back flat head up chin in hands clasped on top of head elbows back bend upper part of trunk to side alternate
8 Same position Turn upper part of trunk to side alternate
9 Good standing position raising arms forward upward, rise on toes stretch tall breathe deeply lower arms sideward down ward lower heels exhale

Fractures of the Vertebral Bodies —Fractures of the spine may be classified according to whether they involve the vertebral bodies or the accessory processes of the vertebrae such as the trans verse or spinous processes or the laminae Of these the first group is the more serious not only because of the possibility of an associated injury of the spinal cord but also because the fracture menaces the weight bearing mechanism of the spine Injury of the spinal cord is a grave complication and except for the few cases with partial or incomplete lesions in which recovery occurs is accompanied by perma nent paralysis of greater or lesser degree affecting all the spinal seg ments distal to the point of injury Injury of the spinal cord is, however the exception and not the rule in fractures of the vertebral bodies contrary to what used to be taught. This has been revealed by the more frequent roentgen ray examinations made in patients with back injuries Studies of the late results of spinal fractures without cord injury however have shown that they frequently give rise to later functional impairment which may be almost as distressing from the economic point of view as paralysis is from the physical

Fractures of the vertebral bodies are generally produced by the compression of one or more bodies between the adjacent vertebral bodies in accidents involving the transmission of force in the long axis of the spine combined with forcible flexion of part of the spine The most frequent site for compression fractures is the dorsolumbar junc tion the point at which the relatively fixed dorsal part of the column joins with the movable lumbar portion As a result of the compressing force the cancellous structure of the centrum crumples producing a wedge-shaped deformity the body being narrower at the anterior than at the posterior border Generally as the body is crushed it mush rooms out and becomes broader than normal All degrees of deformity may be encountered varying from slight to severe The more severe types produce definite kyphosis of the spine at the point of injury

Treatment has for its objectives the correction of bony deformity

1 Lying, hands at back of neck, chin in back flat, breathe deeply raising chest Hold chest and exhale by drawing abdomen in and up relax abdominal muscles to inhale
2 Same position. Pull lower abdomen in relax.
3 Same position Knees bent, flatten back against floor by pulling abdominal muscles in and up
4 Lying flat, stretch whole side, pulling ribs apart contract side abdominal muscles, relax, alternate.
5 Same position Hug one knee, bend other knee over chest straighten leg lower slowly keeping abdominal muscles pulled in and back flat.
6 Hands on ribs Breathe deeply, spreading ribs, hold ribs out and exhale by drawing abdomen in and up
7 Lying face prone hands on side contract back muscles and raise head and shoulders from the bed

When the patient can sit *without the necessity* of protection the following exercises may be given

1 Sitting tall hands on hips, head up chin in back flat breathe deeply raising chest. Hold chest up exhale by drawing abdomen in.
2 Same position. Hands clasped on top of head, elbows back, pull lower abdomen in relax repeat.
3 Same position Stretch one whole side relax alternate.
4 Lie face down over edge of table feet on floor hands clasped in back, head back, chin in roll shoulders back lifting head and upper part of spine relax repeat.
5 Sitting tall head up chin in, abdomen in back flat, hands on hips bend upper part of trunk to side alternate
6 Same position Turn upper part of trunk to side alternate
7 Same position Hands clasped on top of head elbows back breathe deeply pulling chest up hold chest up, exhale by drawing abdomen in.

When convalescence is still further advanced a combination list of exercises may be given as follows

1 Lying hands at back of neck chin in *back flat*, breathe deeply raising chest hold chest up and exhale by drawing abdomen in and up.
2 Same position Knees bent, flatten back *against floor* by pulling abdominal muscles in and up—not a breathing exercise.
3 Same position Hug one knee raise other leg straight lower slowly keeping abdominal muscles pulled in and back flat.
4 *Good standing position* feet straight ahead weight on outside of feet, walk *forward* abdomen pulled in, back flat, head up and back-chin in stretch body tall

5 Good standing position hands on hips pull abdomen in head up stretch body tall breathe deeply raising chest exhale by drawing abdomen in and up
6 Good standing position heels four inches from wall hips shoulders and head touching wall flatten back by drawing abdomen in and up
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fixation of the spine in the corrected position during the period of healing and finally, restoration of function Reduction of the deformity is to be accomplished by extreme hyperextension of the spine. This may be done by forcible manipulation [22] with the patient anesthetized or gradually [24] by the use of a hyperextension frame on which the patient lies the curve of the spine being increased from day to day As soon as complete reduction is obtained a plaster-of-paris jacket is applied extending from the pelvis to the axillae and maintaining the hyperextended position With a carefully molded and close-fitting jacket, the patient may be allowed to be up and about, and the general physiology benefits from this activity The possibility of recurrence of the deformity should be guarded against by roentgen-ray examinations from time to time The plaster jacket should be worn for a period of about eight weeks Following its removal, either a leather or celluloid corset or a spinal brace should be fitted and worn for an additional three to four months This is necessary because the cancellous bone of the centrum does not solidify rapidly, and under slight strain might give way with recurrence of the deformity

Treatment by physical therapy may be started as soon as the plaster jacket is removed Little benefit is to be obtained from the application of radiant heat or from massage of the back because of the deep situation of the fracture in the dorsal and lumbar regions. The part of physical therapy is rather to build up and develop the muscular supports of the spine and to lay a foundation for good spinal function by training the patient to carry his body in the erect posture With correct treatment of fractures of the vertebral bodies beginning immediately after injury and carried through to the end, complete functional recovery may be expected In cases where the nature of the injury is not discovered until late, and therefore in which the early treatment is inadequate the operation of spinal fusion may be indicated later for the relief of pain.

Fractures of the Accessory Processes of the Vertebrae.—The most common fractures of the accessory processes of the vertebrae are those of the transverse processes These are encountered almost exclusively in the lumbar region where the transverse processes are unprotected by attachment to the ribs and are exposed to trauma. Fracture may be produced by direct trauma as from a blow in the flank or by indirect trauma acting through the muscles attached to the transverse processes particularly the iliopsoas One or several of the transverse processes may be fractured on the same side. Rarely the processes may be involved on both sides The fracture may be accompanied by no displacement or by wide separation of the distal from the proximal fragment, a displacement of such degree that bony union between the fragments becomes impossible This type of displacement is usually encountered in the cases with multiple fractures of the processes

There is lack of agreement as to the best method of treatment of fractures of the transverse processes Some surgeons advocate fixation of the spine by the application of plaster-of-paris jackets while others decry the necessity of immobilization It is our own opinion that the fracture is insignificant and that the accompanying soft part injury is the more important. There is no available means of correcting displacement of the fragments so that in the cases with wide separation where bony consolidation is bound to fail it seems the better policy to employ treatment as for a soft part injury only The muscular attachments to the transverse processes are so extensive that if fracture has been produced without displacement there is no likelihood of separation occurring later and the fracture will consolidate as well without fixation as with it provided that the patient is kept quiet As a matter of fact observation of the late results in patients who have been treated by recumbency but without immobilization shows that they make perfect recoveries and are able to perform heavy work. We therefore favor keeping the patients recumbent for a period of four weeks but avoiding the use of retentive apparatus except when indicated by a complicating fracture of the vertebral body

The application of radiant heat and of the superficial type of massage over the injured flank is beneficial and may be started one to two days after the injury At the end of two weeks a régime of postural correction may be started Active exercises should be prescribed for the abdominal sacrospinalis and gluteal muscle groups Additional exercises of flexion and hyperextension of the hip should be given to activate and stretch out the iliopsoas muscle which is presumably involved in scar tissue All movements that provoke pain should be avoided At the end of four weeks the patient may be allowed to be up and about without protection Standing exercises of the postural type should then be started Recovery of function generally occurs rapidly and uneventfully In the rare case where pain persists particularly if there has been wide separation of one of the fragments with failure of bony union excision of the loose fragment may be indicated

Fractures of the spinous processes and laminae are relatively uncommon and as a rule must be treated on the basis of individual indications The fractures without displacement usually require treatment by fixation for a period of about four weeks In the case of displaced fractures it may be necessary to expose the injury by operation and to remove the loose fragment.

Fracture Dislocations of the Cervical Spine.—The injuries of the cervical spine are much more varied than those of the dorsal and lumbar region and include dislocations fracture-dislocations and simple fractures It is not within our province to consider the treatment of the dislocations which is described elsewhere Fractures in the cervical region may be of the typical compression type with wedge-

shaped deformity of the vertebral body but more commonly are of the fracture-dislocation type with disruption of the intervertebral cartilage and anterior displacement of the body of one vertebra upon another The dislocation is generally accompanied by the evulsion of a triangular bony fragment from the anterior superior border of the vertebra below the seat of injury, or there may be a slight compression fracture at this point. There may also be an associated fracture of the laminae of one of the vertebrae In addition fracture of the odontoid process with anterior or rotary dislocation of the atlas on the axis constitutes a special type of injury Cord injury is a much more frequent accompaniment of cervical fractures than it is of fractures in the lumbar and dorsal region When paralysis is present it is usually of the distressing quadriplegic type, and it is almost always fatal after a longer or shorter time.

Correction of deformity is to be obtained by the application of traction to the head with the neck in the position of hyperextension. This may be accomplished gradually by continuous traction with head halter cord, pulley and weight or it may be done rapidly by the application of heavy traction to the head with the patient anesthetized. In either case as soon as reduction is obtained a plaster-of-paris jacket of the Calot type should be applied extending from the pelvis to the chin and including the occiput. This insures maintenance of correction and with it the patient may be allowed to be up and about as soon as the general condition permits

The jacket must usually be worn for a period of about four weeks, following which a leather Thomas collar extending from the chin to below the shoulders is fitted This should be worn for a further period of four to eight weeks

Treatment by physical therapy cannot be started until the end of about eight weeks from the time of injury At this time the collar may be removed temporarily for treatment of the neck, the patient being recumbent. Baking of the neck by radiant heat and massage of the posterior muscles of the neck are useful in preparing the way for active movements Passive mobilization here is dangerous and should not be employed. Active lying exercises of the neck in flexion extension rotation and lateral flexion should be prescribed to be performed daily These are necessary to mobilize the stiff joints and to build up the strength of the muscles so that they may support the weight of the head The use of the collar should be discontinued gradually in proportion to the gain of strength of the neck muscles in order to avoid fatigue The active exercises should be continued until all weakness and discomfort have been overcome.

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CHAPTER SIX

PRINCIPLES OF PHYSICAL TREATMENT OF THE MUSCLE-TENDON SYSTEM TENDON SHEATHS AND BURSAE

JOHN D ELLIS B.S M D

INTRODUCTION

It is necessary for the purposes of treatment, to think of the muscle tendon as a single organ composed of a parenchyma and a stroma. The muscle parenchyma consists of cylinders each approximately 1½ inches long and 0 05 inch in diameter Each cylinder has an elastic sheath of stroma—the sarcolemma. The cylinders are bound together into bundles by the perimysia interna. Larger bundles are enclosed by the coarser connective tissue septa the perimysia externa which in turn are continuous externally with the aponeurosis enclosing the entire muscle and the vaginal sheath of the muscle group It is thus evident that the parenchyma of the muscle is enclosed in a reticulum of stroma just as the parenchymatous organs of the abdomen are and it is easily seen how cirrhosis of a muscle can occur from fibroplasia and subsequent contraction of this stroma after injury or disease This does occur in the course of muscle healing and it is of prime impor tance in the physical therapy of the muscles to prevent this sclerosis All physical treatment of muscle is directed first, toward the stroma to prevent or alleviate fibrosis and secondly toward stimulating the neuromuscular or vasomotor arch which will be discussed later It is a matter of grave doubt whether the parenchyma of the muscle can be favorably affected directly and without the intervening factor or nerve impulse by any treatment except as this therapy mechanically removes metabolites of the muscles into the lymphatics and capillaries brings arterial blood to the muscle cells or removes edema or hemorrhagic accumulation The stroma of a muscle is attached to the tendon and for our purpose the tendon is simply the stroma drawn out and con solidated so that the force of the contracting muscle can be concen trated on a small area of bone In all the muscles inserted directly into bone without the intervention of a tendon—as for example in most of the axial muscles and such appendicular muscles as the deltoids and the gluteals—additional power of contraction is obtained at the expense of leverage and velocity Mackenzie speaks of the "muscularity' of these muscles compared with those which are largely tendinous such as the tibialis anticus peroneal group and long muscles of the forearm

and fingers The amount of musculanity" determines the rapidity of regeneration of the parenchyma and the difficulty of reëducation after paralysis The greater the proportion of stroma the more the tendency to fibrous contraction of the stroma after muscle trauma or inflammation and subsequent ischemia and pressure atrophy of the parenchyma. After injury all connective tissue displays the tendency to subsequent fibrous contraction while parenchymatous tissue like the muscle cylinder, tends to proliferation and regeneration with use without displaying subsequent contraction Carey says "Muscle tissue (parenchyma) is a sensitive indicator, or tensiometer, recording the degree of remittent tension or work to which it is subjected" Hence, all physical treatment of muscle aims at either the prevention or alleviation of fibrosis or the stimulation of the regeneration of muscle parenchyma by motion.

FIG. 1—Insertion of muscle into tendon (after Mackenzie)

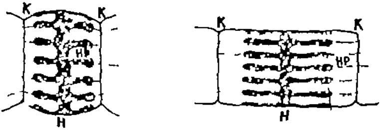

FIG. —Diagram of structure of sarcomere (after Sharpey Schafer) Left-hand figure represents contracted condition the right-hand figure, extended condition. The functional unit of muscle histologically is half a sarcomere. Hensen's line (H) dividing a sarcomere into two independent entities During contraction the clear material "hyaloplasm (HP) flows into the darker "spongioplasm (S) A sarcomere is that portion of a muscle fibril between two membranes of Krause.

The Neuromuscular Arc.—Without the work of Charles Sherington (completed in 1893) we would still be speaking of the "reeducation of the paralyzed muscle" whereas we should speak of the "reëducation of the nervous arc," and while this subject encroaches somewhat on the other chapters of this system an understanding of the basic physiology of the skeletal muscle is necessary for any discussion of remedial exercise or manipulation. The recognition that the

reëstablishment of muscle function is neurologic—not myologic—has found apt expression in a series of articles by Bankart. The mechanism of the reflex muscle arc of Sherington has thus a practical implication for the physical therapist. He must realize that every muscle contraction or stimulation is responsible for an afferent impulse to the cord which is reflected out through efferent impulse to the muscle under treatment. Each time we pinch, stroke or handle a muscle group a stream of impulses is reflected back to the part where they were aroused and also to the opposing muscle groups Thus muscle stimulation is actually nerve stimulation For clinical purposes, it seems reasonable to assume that this motor response to the stimulation of striated muscle is exhibited in two types of activity

1 The quick phasic and transient response seen in the execution of motion

2 The slow prolonged, tonic contraction exhibited particularly by the antigravity muscles which controls the postural activity of the muscles of the lower extremities and trunk of man and to which Sherington applied the term 'plastic tonus"

Muscle Tone.—Sherington has also shown that this postural activity starts a proprioceptive reflex which arising in the muscle *itself* is best stimulated by muscle stretching This gives us a scientific indication for the use of muscle stretching and resisted motion in the reëstablishment of muscle tone by physical therapy after the tonus has been broken by for example powerful and prolonged traction on an extremity for the treatment of fracture It furnishes argument for resisted exercise versus massage in these conditions. The theory that plastic tone is subserved by the sympathetic nerves alone is not at present, proved to be exact Kanavel Pollock and Davis—and later Ransom and Hinsey—could detect no significant loss of tonus in the decerebrate animal when sympathetic denervation was performed. The *importance of this mooted question to the physical therapist* is involved in the question as to whether the caloric stimulation of a part which, it is well known affects the vasoconstrictor apparatus or the vasodilatory mechanism is capable also of aiding in the reestablishment of muscle tonus

Muscle tone or tonus is in the words of Sampson Wright "one of the most misused terms in physiology and a sharp definition is essential It is usually defined as a state of slight constant tension which is characteristic of all healthy muscle and serves to obviate the muscle's taking up slack when it enters upon its contraction But as he points out, this explanation is inadequate as tone is not uniformly distributed *in all muscles* and the latency of toneless contraction is less than 1/100 of a second.

Decerebrate Rigidity—Much light has been thrown upon the rationale of the prevention of contracture in paralyzed muscles and the

practical considerations to be observed in the restoration of function, by studying the mammalian preparations "decerebrated" by transection through the hind part of the midbrain In such animals the limbs are rigidly extended, the mouth closed, the neck in opisthotonos, while the back is arched and the tail raised. The position of the limbs is difficult to alter and the muscles, on palpation are firm and contracted. When placed on its legs the animal will remain standing This position is maintained reflexly If the posture nerve roots coming from a limb are severed, the rigidity at once disappears from the limb The rigidity is, therefore, reflex If the limb is skinned, rigidity persists. It is reasonable to assume, therefore that the afferent impulse of the reflex originates in the deep structures i e, the muscles tendons etc. If all the nerves to the muscles of an extremity except, for instance, that to the quadriceps are cut, only the tone in this muscle remains. This nerve to the quadriceps is, of course a mixed one, containing both afferent fibers from special sense organs in the muscle spindles and in the tendons and motor fibers. It seems clear that the tone of a muscle depends primarily on impulses arising in the muscle itself We have here a somewhat unfamiliar type of reflex whose purpose it is to maintain postural tone We are particularly concerned with the reflex for the maintenance of position because it affects the muscles of the extremities unequally—that is it is manifested in those muscles which counteract gravity and prevent the animal from sinking to the ground. The muscles which are found contracted in the decerebrate preparation are termed the antigravity" muscles This purposive and coordinated reflex affects also the muscles antagonistic to the antigravity muscles by reciprocally inhibiting their contraction

Decerebrate Rigidity in Man.—Decerebrate rigidity of an extremity is produced in man by brain lesions temporary or permanent at the same level as those produced in experimental animals and also by unilateral or bilateral lesions of the pyramidal tracts. The practical application of splints to prevent contracture and deformity in these lesions depends on a comprehension of the distribution of these posture reflexes While the position of the legs in man with the knees extended and the ankles plantar flexed (extended) corresponds to the position of the hind legs in the decerebrate animal the position of the arms is different The arms of man not used in locomotion have changed in postural reflex pattern The arms are drawn across the chest, with the forearms partially flexed The forearms are somewhat pronated and the wrists thumbs and fingers are flexed. One recognizes here the position of the end result commonly seen in hemiplegia in which no protective splinting of the weaker muscles has been employed and no other physical therapy undertaken. This position in man is due to the release of a function of the lower brain uninhibited by the function of the red nucleus which is concerned with the maintenance of normal body posture and normal muscle tone. It is the center for the "righting

reflexes" by means of which the body is restored to its original posi tion after it is displaced or after loss of equilibrium. These reflexes must return before equilibrium and coördination are restored after muscle or muscle-nerve arc impairment This is the most urgent argu ment for active coördinated remedial exercises in muscle and tendon rehabilitation and retraining

Myostatic or Stretch Reflexes.—The return of normal "plastic tone to antigravity and other muscles of the lower extremity and to those muscles of the arm displaying this phenomenon after disease or injury of the muscle partial or temporary damage of the reflex arc or long and powerful traction in the treatment of fracture can in part be accomplished by the stimulation of the stretch reflex. The physi ology and method by which this reflex is therapeutically elicited is interesting In the decerebrate dog Liddell and Sherington found that a reflex response producing a contraction of 2 Kg tension could be produced by a stretch of a few millimeters i.e., less than one per cent of the initial length of the muscle. As the stretch is applied rapid development of tension occurs As an evenly applied pull is exerted an increasing number of receptors in the muscle are successively brought into action and reflexly an increasing number of muscle fibers contract. While the stretch is maintained more or less steady motor response is elicited without fatigue for as long as one half hour This action results in metabolic activity in the muscle and is a functional stimulation of the muscle. This type of muscle stimulation appears quite similar to the muscle rigidity of the abdominal wall reflected over the segmental representation of the innervation of the inflamed intraperitoneal viscus. It is also quite analogous to the therapeutic effect of the spasm elicited in the erector spinae muscles and the quad ratus lumborum by kneading or stretching these tonically contracted muscles in an arthritic spine or a spine presenting trauma to the joint capsules and ligaments

Had Hugh Thomas understood the sound physiologic basis upon which the practice of passive motion and manipulation now rests he would not have uttered that pronouncement which backed by the weight of his great prestige and authority has retarded the development of physical treatment and especially scientific massage manipu lation and passive motion among the orthodox profession even till the present time and fostered the development of schools of peripatetic 'bone setters" The full quotation of his momentous dictum is as follows

For many years after the commencement of my experience in surgery I had the opportunity of observing the practice of those who had acquired a good reputation for skill as successful manipulators I have resorted to these performances and for many years believed that my interference assisted recovery Long ago I have from a more

complete knowledge confirmed by crucial tests so selected them that *I cannot find suitable cases upon which I would perform the deception known as passive motion* And whereas in the early days I believed that much aid was given in recovery by passive motion, now I know by well attested facts that some of my marvels of my past practice had been marred by the very treatment I was so proud of'

This view, from so celebrated an authority, formulated and unremittingly reiterated for the 15 years following 1875 substantiated the enduring opinion inculcated in the mind of the British regular practitioner by John Hilton s notable volume 'Rest and Pain," based on his principle of treatment by rest without massage or manipulation. He had, from 1853 to 1878, successfully and brilliantly preached a system of therapeutics in which exercise, active and passive, had no more place than massage or manipulation. The principles of Hilton and Thomas are still strongly operative in America in influencing the old-style regular practitioner against physical therapeutic measures.

The Vasomotor Reflex Arc.—Besides the conception of the muscle-neural arc as a single apparatus, a motor system, we are concerned with another reflex mechanism—the vasomotor reflex arc, which controls the supply of blood to the muscle and is impaired in efficiency in muscle subjected to accident or disease The practical question arises as to the best means of maintaining health in a muscle which is paralyzed (the muscle-neural arcs are disturbed) until the restoration of nervous control. Suppose the efferent moiety of the arc is interrupted. In the early stages of degeneration of this paralyzed muscle, massage (which is not a stimulus to muscle repair but a stimulus to the neural arc) cannot be expected to do anything but harm if the arc is entirely interrupted. This muscle is as much in need of rest as a fractured bone.

The question immediately arises first, as to whether there is any satisfactory means of stimulating the vasomotor mechanism and secondly whether stimulation of this arc will have a beneficial effect on metabolism of the flaccid and paralyzed muscle.

Fortunately if the vasomotor arc is intact something can be accomplished in maintaining the metabolism of the damaged muscle until the voluntary control returns The application of thermal stimulation aids in maintaining arterial supply and venous return in the muscle.

Physiology of the Painful Muscle—It is of course common knowledge that the traumatized inflamed muscle is painful on motion. It is the hope of the physical therapist to relieve this pain by treatment. The origin of this muscle pain is apparently twofold

1 Spastic contraction of the peripheral arteries in certain clinical conditions is generally admitted The clinical entity known as Raynaud s disease well illustrates this phenomenon The exacerbations of the pain have been satisfactorily demonstrated to correspond to the

attacks of *arterial spasm.* Odermatt regarded spasm of the arteries as quite similar to intestinal colic He found that sudden distention of the arterioles produced painful sensations Where irritating substances were injected into arteries no pain was produced unless the irritant reached the capillaries He concluded that under these circumstances at least the impulses giving rise to pain arose in the capillaries and not in the larger vessels Odermatt proved furthermore that painful sensations are produced by distention of arteries regardless of their size He believed that capillaries manifested sensibility to changes of caliber—both dilatation and contraction. Intravenous injections of salvarsan or uroselectan as is well known cause pain during the puncture of the vein wall and if the wall is damaged and becomes spastic, painful sensations may persist for long periods Stimulation of the perivascular sympathetic plexus is probably responsible for this phenomenon However different arteries are found clinically to respond differently to obliteration by surgical ligation All arteries are not equally sensitive to the compression resulting from trauma. Ligation of the superior thyroid artery often causes pain radiating to the lower jaw while ligation of the inferior thyroid is notably painless Odermatt found that ligation of the common carotid iliac and part of the mesenteric supply was painful He found that some arteries which were sensitive to ligation were painful when distended. The true paths of the afferent painful impulses from the muscles are not entirely established. It seems definitely established however that these impulses pass through fibers connected with the posterior root ganglia of the spinal cord and are no different from sensory nerves elsewhere in the body they simply happen to travel in the same sheaths with so-called sympathetic nerves In the same *sympathetic trunks the efferent vasoconstrictor fibers may pass down* to the vessels. Vasodilatation is probably not so simple a reaction as vasoconstriction Lewis has convincingly demonstrated that dilator fibers may be present in the sensory nerves and not act directly on the vessel but cause the liberation in the tissues of a histamine-like body the "H-substance which dilates capillaries by a direct chemical action on their muscle walls

2 Muscle ischemia, either from vascular spasm or pressure on the blood vascular system of a muscle by edema, extravasation of blood or the cellular products of inflammation may cause pain on active motion Lewis finds that pain may develop in contracting muscle even without arterial spasm His observations lead to the view that the stimulus causing pain is determined by some chemical or physiochemical agency within the mass of muscle When a muscle contracts, a release of metabolites occurs within the fibers and obviously these may diffuse and cause the painful stimulus Histamine or the 'H substance is also liberated in injured or inflamed muscle This may be the stimulating agent At any event a stimulation of the absorption by the circulation of metabolites or histamine-like substances or the

complete knowledge confirmed by crucial tests so selected them that *I cannot find suitable cases upon which I would perform the deception known as passive motion* And whereas in the early days I believed that much aid was given in recovery by passive motion, now I know by well attested facts that some of my marvels of my past practice had been marred by the very treatment I was so proud of'

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Physiology of the Painful Muscle.—It is, of course, common knowledge that the traumatized inflamed muscle is painful on motion. It is the hope of the physical therapist to relieve this pain by treatment. The origin of this muscle pain is apparently twofold

1 Spastic contraction of the peripheral arteries in certain clinical conditions is generally admitted The clinical entity known as Raynaud s disease well illustrates this phenomenon The exacerbations of the pain have been satisfactorily demonstrated to correspond to the

attacks of arterial spasm Odermatt regarded spasm of the arteries as quite similar to intestinal colic. He found that sudden distention of the arterioles produced painful sensations Where irritating substances were injected into arteries, no pain was produced unless the irritant reached the capillaries He concluded that, under these circumstances at least, the impulses giving rise to pain arose in the capil laries and not in the larger vessels. Odermatt proved furthermore that painful sensations are produced by distention of arteries regard less of their size. He believed that capillaries manifested sensibility to changes of caliber—both dilatation and contraction Intravenous in jections of salvarsan or uroselectan, as is well known cause pain during the puncture of the vein wall and if the wall is damaged and becomes spastic, painful sensations may persist for long periods Stimulation of the perivascular sympathetic plexus is probably responsible for this phenomenon However different arteries are found clinically to respond differently to obliteration by surgical ligation. All arteries are not equally sensitive to the compression resulting from trauma. Ligation of the superior thyroid artery often causes pain radiating to the lower jaw while ligation of the inferior thyroid is notably painless Odermatt found that ligation of the common carotid iliac and part of the mesenteric supply was painful He found that some arteries which were sensitive to ligation were painful when dis tended. The true paths of the afferent painful impulses from the muscles are not entirely established. It seems definitely established, however that these impulses pass through fibers connected with the posterior root ganglia of the spinal cord and are no different from sensory nerves elsewhere in the body they simply happen to travel in the same sheaths with so-called sympathetic nerves In the same sympathetic trunks the efferent vasoconstrictor fibers may pass down to the vessels Vasodilatation is probably not so simple a reaction as vasoconstriction Lewis has convincingly demonstrated that dilator fibers may be present in the sensory nerves and not act directly on the vessel, but cause the liberation in the tissues of a histamine-like body, the 'H-substance" which dilates capillaries by a direct chemical ac tion on their muscle walls

2 Muscle ischemia, either from vascular spasm or pressure on the blood vascular system of a muscle by edema, extravasation of blood or the cellular products of inflammation may cause pain on active motion Lewis finds that pain may develop in contracting muscle even without arterial spasm. His observations lead to the view that the stimulus causing pain is determined by some chemical or physiochemical agency within the mass of muscle When a muscle contracts a release of metabolites occurs within the fibers and obviously these may diffuse and cause the painful stimulus Histamine or the "H substance is also liberated in injured or inflamed muscle This may be the stimulating agent At any event, a stimulation of the absorption by the circulation of metabolites or histamine-like substances or the

edematous fluid produced by trauma or by muscle action, may rectify an abnormal status of the vasoregulatory apparatus, this aids in the alleviation of pain on active motion of injured or diseased muscle. We have a satisfactory agent for the relief of vasospasm in deep heat (diathermy) The application of diathermy for this purpose has been recently described by de Takats In the reëstablishment of the balance of the vasomotor arc, the approved physical treatment is "contrast baths,' or the alternating application of heat and cold Superficial and brisk skin massage, or effleurage is reflected through the vasomotor arc to the muscle, inducing capillary dilatation of the muscle beneath, but it is doubtful if massage of the muscle itself is ever justifiable for this purpose and, in the flaccid paralyzed muscle, probably is actively detrimental to the maintenance of vasomotor stability and metabolic activity

Active Motion.—Muscular action of a voluntary nature comprehends a more intricate set of changes in muscle status than is usually suspected The single action of muscular contraction on the part of one muscle or muscle group, which produces the desired effect of shortening one arm of a lever and moving a joint at its fulcrum or center of motion, is accompanied by two other types of muscle action described as antagonistic and synergic. Muscle reëducation and the reëstablishment of muscle coördination must contemplate the reëstablishment of all these types of action for every movement reëducated. When a voluntary stimulus causes one muscle to contract, its opponent muscle or group, according to the law of reciprocal innervation, is inhibited, thus facilitates motion of the joint acted upon A muscle fiber cannot be in a state of physiologic contraction and relaxation at the same time For any muscular action exerted upon a joint, several muscle groups are involved We may recognize those which contract, those which relax and those which steady the moving parts, as follows

(a) The protagonists agonists or prime movers constitute the first class. In making a fist, the protagonists are the flexor muscles of the thumb and fingers

(b) The antagonists constitute the second class and in the above motion are those which would interfere with the accomplishment of the action of the flexors i.e the extensors of the thumb and fingers. However the relaxation of the antagonists is no more complete and unqualified than the contraction of the flexors Flexion is not an unregulated action in regard to extent and force and relaxation of the opposing extensors is essentially an active not a passive state It is therefore not intended to convey the notion that the antagonists relax completely or immediately but that there is always a nice muscle balance In slowly accomplished motion the antagonists react slowly and harmoniously to every nuance of motion produced by the protagonists During violent contraction of the protagonists they relax quickly and almost completely In sudden action the slack produced

by sudden relaxation is taken up by the resilience of the elastic muscle.

(c) The third class—the synergic or fixing muscles—displays an action which is secondary and designed to aid the prime movers of the joint. In clenching the fist, the synergists are the extensors of the wrist, which aid finger flexion by lengthening the rigid arm of the lever by including in it the ulna and radius Even the triceps may contract to steady the elbow when the fist is powerfully clenched In reëstablishing strength of motion in weakened flexor sublimis and profundus muscles every physical therapy technician has noticed how the synergists if uninvolved in the pathology will tend to extend the hand at the wrist when voluntary finger flexion is attempted by the patient This constitutes an overaction of the synergists

Muscle Balance.—As an adaptation to physiologic need certain groups of muscles in the human body have developed in strength of motion and resistance to fatigue out of proportion to their opposers In the lower limb for instance the antigravity muscles—which are the protagonists in enabling a man to stand upright—are, in general, more powerful than their opponents while in the shoulder the adductors and internal rotators overshadow the abductors and external rotators Another example is the relatively greater strength of the flexors than of the extensors of the wrist and fingers. In splinting or immobilizing a joint in a cast, the principle of muscle balance must be remembered as it is important to put the muscle groups at rest in a position favoring the reëstablishment of motion in the weaker group as against the stronger The joint must be flexed somewhat in the direction of the motion of the weaker group More important still is the admonition against allowing a paralyzed joint to assume the position of contraction of the stronger group e g allowing an injured shoulder to be carried in a sling in the position of adduction and internal rotation until shortening occurs in the more powerful adductors and internal rotators More damage is done in the weaker group by allowing overstretching than in the stronger group by allowing contraction and fibrosis Sir Robert Jones claims that in flaccid paralysis of muscle a single lapse in the protection of the weaker group against overstretching will set back the ultimate recovery of muscle function for months

Muscle Rest.—The position of fixation of a joint when only one muscle or muscle group is injured inflamed or flaccid from paralysis constitutes an entirely different set of desiderata. The normal muscle can be considered as possessed of two functions—that of contraction and that of relaxation During the exhibition of either of these functions the contraction of a muscle or the relaxation of a muscle to compensate for the contraction of its opponent, a muscle may be described as being in a state of irritation. To be more technical

Meyerhof and others have described the histologic appearance of striated muscle fibrils as consisting of an accordion like arrangement of 'spongioplasm" suspended in a more fluid 'hyaloplasm" which permeates the interstices of the spongioplasm" during relaxation and is expressed from between the folds of the accordion during contraction, both states representing a change in configuration from the resting stage.

The position of the various joints at which the opposing groups of muscles are balanced varies with the anatomy of the joint and usually coincides with the largest capacity of the joint cavity Generally it is identical with the most useful position or the position of election for ankylosis. Thus if we desire to put the joints and muscles producing rotation of the radio-ulnar joints at rest, a point midway between pronation and supination is chosen, while, if the knee and its flexors and extensors are to be put at rest, a position of slight flexion is desirable However when one set of muscles is weakened or paralyzed, it is rested when the joint is in such a position that the opposers are in a state of relaxation or elongation beyond the normal status considered to represent equilibrium for the particular joint. This is described as the zero position" and represents the position from which it is most advantageous to begin the reëstablishment of active motion since the minimum of muscle strength is necessary in the weakened muscle to produce the first few degrees of joint motion. A weakened muscle cannot always produce voluntary motion from a position of greatest leverage and greatest relaxation of muscle. This is exemplified in the deltoid weakened by paralysis, which initiates no abduction in the arm hanging against the side of the erect patient, but can abduct an arm beginning with the arm lying at 45 degrees abduction with the patient in the supine position Another example is the ability of the flaccid quadriceps femoris to flex the thigh of a patient lying on that side with the thigh already flexed a few degrees and its inability to initiate flexion of the thigh with the patient standing and with the weight of the leg exerted against the weakened flexor An apparently completely paralyzed muscle is often found when tested in zero position," to exhibit some function under circumstances calling for a minimum of tensile strength and contraction. This condition of 'poverty of motion may exist in motor paralysis of a muscle which, even by electrical tests appears to be completely functionless. Muscle or neuromuscular arc retraining of weakened muscles of a patient floating in water takes advantage of the principle of utilizing minimum function in initiating motion by abolishing the weight of the extremity which is suspended in a medium of practically its own specific gravity Such methods of reëducation are now considered infinitely more effective than stimulation by electric currents or massage Resisted motion, eliciting the stretch reflexes and thermic stimulation to reëstablish vasomotor tone with the increasing strength of the muscle fit smoothly into this scheme of muscle rehabilitation

Physical Treatment of Muscle Tendon Pathology

Contusions and Sprains.—The management by physical treat ment of the acutely traumatized muscle and tendon is rather uni versally standardized and generally accepted as consisting of rest elevation and the relief of edema and passive congestion. Little can be added to the general indications for treatment. The application of physical treatment to injuries of soft parts presupposes that a definite diagnosis has been made This assumption cannot be made without complete investigation of the possibilities of underlying bone and blood vessel injury In 1912 Ross and Stewart provided ample experi mental evidence that the ligaments have a greater tensile strength than the bony prominences to which they are attached They showed that when there is a so-called tear of a ligament, this takes place at the insertion of ligament into bone in the great majority of cases and that, with the tearing off of this ligament attachment a fragment of cortex is wrenched loose The common type of ligamentous injury then, is a periosteal injury with the avulsion of an apophysis of bone. These ligamentous injuries are in reality fracture-sprains not simple sprains The same mechanism is operative when a tendon is injured by sudden stretching as for instance in falls on the extended arm, where the flexor muscles of the wrist and fingers and the extensor muscles of the elbow are forcibly stretched Fracture is much more common than tear of ligaments or muscles and if a muscle-tendon system is torn off a fragment of bone at its insertion comes off with it The indications for treatment of this 'sprain fracture" are entirely distinct from the treatment of a simple strain of muscle or tendon X ray diagnosis is essential here Fractures of the greater tuberosity of the humerus are easily mistaken if not x rayed for sprains about the shoulder and slight cortical avulsion Fractures of the great trochanter tip or of the base of the fifth metatarsal, where the peroneus brevis inserts are easily overlooked and considered respec tively as gluteal strains or peroneus tendon sprains.

Injuries of the back are frequently dismissed from serious con sideration as merely muscle contusions and physical treatment is directed on a basis of this diagnosis Writing on the ease with which mistakes are made in back contusions Cohn makes several important points

1 The diagnosis of contusion is not justified unless everything else is eliminated

2 Proper investigation will reveal a greater frequency of fracture of the transverse processes incomplete fracture of the vertebral bodies and sacral injuries

3 Early and careful examination with detailed records of our findings will eliminate damage suits.

4. Patients will suffer less permanent disability if their conditions are properly treated in their early stages.'

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The best guide as to the depth of massage is pain. The technician must be repeatedly warned and the patient advised that massage to be effective and not injurious must keep below the threshold of the pain impulse

The question of the early employment, after contusion of heat or cold depends also upon the patient s reaction Severe angiospasm is painful and if the application of either heat or cold or the contrast bath of alternating heat and cold, leaves a painful extremity or muscle, it is contraindicated. In most cases, however heat is the choice of the patient However it is important to note that this is not always true.

In 1917 Leriche began to make oscillometric tests on contused extremities His associates Flerez, Albert, and later Fontaine and Miloyevitch have repeated and elaborated these tests. After a con tusion of any part in man the peripheral nerve endings are excited and by reflex action the equilibrium of the vasomotor system is disturbed These oscillometric tests prove every traumatism to be above all, a traumatism of "vasomotoricity The disturbance of the vasomotor equilibrium expresses itself sometimes after a brief stage of constriction, by active vasodilatation. As a rule these vasomotor changes are transitory and hence of no importance to the physical therapist Sometimes, however the disequilibrium persists and either (1) a chronic spasm and constriction of vessels or (2) vasodilatation becomes a permanent state. Furthermore Leriche believes that the vasodilatory state is not continuously the same there being at the beginning a varying period of active vasodilatation with local hyper emia, followed finally by passive vasodilatory changes with cyanosis. It is difficult to analyze the reasons for this sequence or to account for it definitely on a basis of our present knowledge of the autonomic nervous system control of the caliber of blood vessels. It presupposes an active vasodilator mechanism which, as has been mentioned above has not been satisfactorily demonstrated in man. Individual susceptibility may be the deciding factor With Policard Leriche has demonstrated that an atrophy of bone as well as of muscle, occurs concomitantly with vasodilatation in the adjacent soft parts In the first class with beginning chronic vascular spasm, it is important to secure the return of the normal vasomotor balance by gentle massage, mechanotherapy graded exercises and, above all penetrating heat by diathermy All these means of stimulating vasomotor tone may easily be overdone and the danger is greater in too energetic than in too moderate treatment.

In the group with vasodilatory reactions unless elevation of the part and bandaging to relieve the swelling are instituted edema and fibrosis may ensue, like the so-called 'brawny edema" of lymphatic obstruction plus infection. Leriche believes that the type with vasodilatations should be treated by the topical application of cold water or even ice at frequent intervals He raises the question of the possible value of local blood-letting an antiquated method for the relief of

Especial care must be displayed in the study of sprained and tender muscles to determine whether the trauma described by the patient was really severe enough to have resulted in the degree of tenderness, spasm and loss of motion displayed by the injured muscle-tendon system On examination of the patient for tenderness and increased consistency of the various affected muscles, the examiner must always try to find a suitable mechanical explanation in terms of muscle function The origin insertion and course of the affected muscle should correspond mechanically to the probable lines of transmission and dissipation of the traumatizing force If the subjective symptoms are too severe or the lines of transmission of force unlikely after a given trauma a search for other pathology than muscle-tendon injury must be made One of the most spectacular mistakes ever made by an osteopath stands out in the mind of the writer This occurred when he witnessed as a medical student, the removal of a gangrenous appendix from the tip of which protruded one-half the length of a pin. This pin had been swallowed weeks earlier and had caused severe pain and spasm of the psoas muscle, into which it had penetrated. Prior to the operative removal following the advent of gangrenous appendicitis the patient s tender and contracted right psoas muscle had been thoroughly and conscientiously massaged and manipulated by an osteopath. A retrocecal appendicitis can easily be treated for a strained psoas muscle and an infected kidney for a strained and spastic quadratus lumborum muscle.

Injuries of the muscles about the elbow are found to conceal a fracture of the radial head in a surprising number of cases since the advent of routine x ray examination of injuries and this is most important, since many of these fractures deserve immediate removal of the radial head or the offending fragments One of the most easily confused injuries is that of transverse fracture of the scaphoid, which is commonly thought to be a sprain of ligaments or a traumatic tenosynovitis about the wrist, because the first x ray picture does not reveal the delicate fracture line while another view taken a week later after the slight absorption of the bone margins at the fracture (which constantly occurs in fractures) then allows the fracture to be seen as a radiolucent defect.

As to the use of elevation and rest by splints or light bandaging for the severely contused muscle there is little controversy Regarding the time however at which effleurage for the purpose of dissipating the edema or products of inflammation or deeper massage to elicit the stretch reflexes or stimulate the vasomotor arc of the muscle, should be initiated the opinions of different technicians vary Some believe that passive motion or resistive exercise should almost entirely supplant massage This probably depends on the psychology of the masseur In general it can be safely stated that the more ignorant the masseur the more his tendency to damage injured muscle by deep massage during the process of healing of the damaged parenchyma.

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Robert Jones has often pointed out, these surgeons prejudice is based on the faulty technic of their procedure In forcible manipulation the following precepts are mandatory

1 Preliminary baking massage and manipulation must be continued until no further improvement of function can be obtained

2 No acute or subacute arthritic" joint must be manipulated, or its attendant muscles forcibly stretched.

3 The muscles to be stretched must be massaged while the stretching is taking place.

4 The operation must be performed in stages

5 At each stage one motion only can be attempted. For instance only the adductors of the shoulder can be stretched at one operation. Internal rotation and external rotation must be accomplished in two more separate operations

6 Motion is continued only until adhesions about, or fibrous bands within, a single muscle or group once are felt to lengthen Often a snap accompanies the breaking of adhesions

7 The new position of the lengthened muscle must be maintained after each operation.

8 Heat and massage of the treated muscle must be continued until the tenderness resulting from the forcible stretching has disappeared before another group is stretched

By this graded method of forcible manipulation extended over a period of several weeks residual shortening and stiffness in contracted muscles may be alleviated. This method of manipulation should however be employed only after heat, massage and active and passive motion have failed fully to restore function In contraction of the flexors or extensors of the fingers continuous elastic traction may expedite the ordinary methods of physical therapy

Volkmann s Ischemic Contracture

Stromeyer (1838) and Volkmann (1869) described this disastrous complication of injury and subsequent ischemia producing a flexion contracture of the fingers, wrist and forearm. This condition well exemplifies the necessity of coöperation of surgeon physical therapist and patient in the treatment of every phase and stage in its development. Once established as an extensive degeneration and atrophy of muscle parenchyma, with fibrosis of the muscle-tendon stroma and secondary involvement of nerve trunks and joints it challenges the most expert attempts at reconstructive surgical treatment.

The forearm is the commonest region involved but other anatomic locations may be affected, e g the leg where long muscles are encased beneath deep and unyielding layers and septa of fascia. Volkmann himself considered the contracture as due primarily to the interference with the circulation of muscle cells from tight splinting with subse-

congestion Later, he advises alternate local or general douches of hot and cold water, as in the hydrotherapy practiced at Aix-les Bains.

The Rupture of Muscles and Tendons.—The rupture or partial rupture of a muscle or tendon may result from muscular violence or from a direct sharp blow on a contracted muscle or tense tendon. If the attachment to a bone is avulsed, it must, in most cases be surgically repaired Immediate repair of ruptured muscles and their sheaths and tendons should be undertaken before contracture of the muscle and fibrosis of the stroma have occurred If immediate repair is not feasible, coaptation splints should be applied to the muscle belly to prevent contraction and separation of the ruptured parts as far as this is possible The part should furthermore be put up in the position assumed by the muscle during contraction, in order to approximate the separated parts and prevent shortening and contracture of the opposing muscle group After repair, the muscle must be immobilized in this same position and the application of physical treatment, except heat, is contraindicated for a period of six weeks to two months. After ten days to two weeks however a repaired tendon can be passively moved daily by gentle manipulation of the joint involved in its motion through an arc of a few degrees The splint should be replaced immediately without the exhibition of any active motion The same consideration in treatment is shown the avulsed tendon attachment, after the spicule of bone it carries has been nailed back.

The Chronic Traumatized Muscle.—The patient often presents himself for treatment after fibrosis and contracture of an injured muscle and sometimes of its synergists have already occurred The question of gradual or forcible stretching presents itself The gradual stretching of a shortened muscle is distinctly an art. The novice almost always expects results to appear too rapidly Massage, after baking or diathermy has somewhat softened the muscle is the routine approach. Pain or at least discomfort, during treatment does not prevent a satisfactory progress of recovery but an unusual amount of skill is necessary to decide what degree of pain indicates damage to the muscle. The only criterion is the question as to whether daily improvement follows any given degree of massage and stretching In such a course of treatment a point is often reached where no further improvement is attained or where farther motion of the adjacent joint is unbearable Here if one is convinced that no tuberculous or gonorrheal infection exists in the joint, and no active arthritis exists a forcible manipulation *of the joint and attendant muscles*—or rather a series of manipulations—can be attempted The present tendency of many capable surgeons strenuously to condemn forcible manipulation is due to their own unfortunate experience in *too forcibly* manipulating a stiff *joint* and shortened muscle groups under anesthesia. One case definitely aggravated has made them wary of this method of treatment. As Sir

The onset of symptoms the ischemic stage is often acute and follows the damage to the muscles within 12 hours Before the extrinsic pressure of the splint or cast is removed or the circulatory obstruction is relieved the part distal to the injury becomes cyanotic or gray cold and pulseless edema develops and the pain is severe Flexion of the fingers begins to appear and attempts to correct this aggravate the pain Removal of the cast alleviates the pain to some extent, but the swelling continues to be present for several days, though the pulse returns The flexor pronator group now feels firm to the examining finger and may be palpably friable Loss of power is noted in this muscle group and skin sensation over the median or ulnar distribution may be decreased The patient finds the hand now practically useless in grasping

Some cases develop more gradually with a smaller degree of pressure or obstruction on removal of a splint, or on examining an injured arm several days after immobilization, the affected muscles are found to be firm and have started to contract. Pronation and supination are limited and the forearm tends to pronate if the pronator radii teres is involved Often elbow motion is limited On removal of a cast or splint if muscles and skin are found sloughing from pressure the harm has been accomplished even though no warning pain has been experienced

Treatment.—The treatment at various stages furnishes a striking and typical example of the importance of adopting the viewpoint of muscle protection treatment during all phases of the surgical management of injured extremities. Propaganda against circular casts for the injured elbow and forearm and attempts at forcible retention of reduction or coaptation of fractures by splints has been thorough and in general effective. Thorough training in the surgery of injury includes inculcation of the principle of complete and anatomic reduction of fractures of the humeral condyles with early open operation if gently applied closed methods fail The education of every medical student must feature the dangers of any fracture treatment which leaves the part painful after reduction has been accomplished In elbow fractures in which the Jones position of complete flexion and supination—even if the fractures by subsequent roentgenologic check up are seen to be perfectly reduced—leaves the elbow swollen and cyanotic or pulseless the complete flexion must be discontinued. Every elbow or forearm fracture or injury must be inspected at frequent intervals during the first few days for the advent of any of these dangerous symptoms of impaired circulation In some injuries of the forearm with or without fracture it is wise to decompress the muscles by lateral slits through the deep fascia. It is better to employ elevation and traction until any unusual degree of swelling disappears than to insist on immediate reduction. Hot dressings and diathermy aid in the relief of intrinsic pressure of moderate degree Immediate

quent ischemia and ischemic necrosis The degeneration of muscle was thought by Bardenheuer to be due to toxic necrosis as the result of venous stasis A third explanation is that of J J Thomas, who believed that nerve involvement was not a complication but a necessary etiologic factor in association with ischemia and varying grades of venous obstruction It is apparent that extrinsic pressure from the application of a tight splint, circular casts or Esmarch bandages is a common cause of the condition, but Bardenheuer found that 8 per cent of the cases occurred in fractures where no splinting or immobilization treatment was administered Jepson, and later Lewis demonstrated that an accumulation of blood or the advent of edema in the deep vaginal space (Prentiss) on the flexor surface of the forearm can produce ischemic contracture Jones states that 19 out of 40 cases were associated with fracture about the elbow Meyerding found in 128 cases treated at the Mayo clinic, that about 5 per cent had had

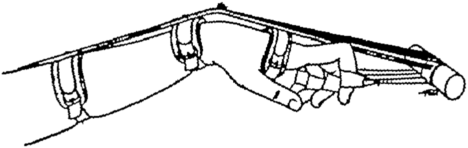

FIG. 3—Diagram of elastic extension apparatus for early ischemic contracture.

no fracture and that in 40 per cent of the fracture cases the humerus was involved and had been treated by the Jones method of complete supination and flexion of the elbow This position is probably ideal when the condyles are completely reduced and not left displaced in a backward position with the upper fragment forced into the antecubital space cutting off the arterial blood supply and blocking the venous return Murphy first suggested early incision by an anterolateral ulnar slit into the deep vaginal space and Dean Lewis has repeated this.

In a few hours after compression by either extrinsic or intrinsic pressure upon the flexor pronator group of forearm muscles has been established the pathologic picture of cyanosis and swelling appears. Irretrievable damage is done to the tissues within a short time. The muscles become necrotic, friable and anemic Later they are represented by fibrous cords and the vessels and nerves to the forearm and hand are encased in a fibrous mass. The bones become softened and ischemic atrophy and the atrophy of disuse develop With the establishment of muscular contracture and rigidity fibrous ankylosis limits the motion of the joints

The onset of symptoms the ischemic stage is often acute and follows the damage to the muscles within 12 hours Before the extrinsic pressure of the splint or cast is removed, or the circulatory obstruction is relieved the part distal to the injury becomes cyanotic or gray cold and pulseless, edema develops and the pain is severe. Flexion of the fingers begins to appear and attempts to correct this aggravate the pain Removal of the cast alleviates the pain to some extent, but the swelling continues to be present for several days, though the pulse returns The flexor pronator group now feels firm to the examining finger and may be palpably friable Loss of power is noted in this muscle group and skin sensation over the median or ulnar distribution may be decreased The patient finds the hand now practically useless in grasping

Some cases develop more gradually with a smaller degree of pressure or obstruction on removal of a splint, or on examining an injured arm several days after immobilization the affected muscles are found to be firm and have started to contract. Pronation and supination are limited and the forearm tends to pronate if the pronator radii teres is involved Often elbow motion is limited On removal of a cast or splint if muscles and skin are found sloughing from pressure the harm has been accomplished even though no warning pain has been experienced.

Treatment.—The treatment at various stages furnishes a striking and typical example of the importance of adopting the viewpoint of muscle protection treatment during all phases of the surgical management of injured extremities Propaganda against circular casts for the injured elbow and forearm and attempts at forcible retention of reduction or coaptation of fractures by splints has been thorough and in general effective Thorough training in the surgery of injury includes inculcation of the principle of complete and anatomic reduction of fractures of the humeral condyles with early open operation if gently applied closed methods fail The education of every medical student must feature the dangers of any fracture treatment which leaves the part painful after reduction has been accomplished In elbow fractures in which the Jones position of complete flexion and supination—even if the fractures by subsequent roentgenologic check up are seen to be perfectly reduced—leaves the elbow swollen and cyanotic or pulseless the complete flexion must be discontinued Every elbow or forearm fracture or injury must be inspected at frequent intervals during the first few days for the advent of any of these dangerous symptoms of impaired circulation. In some injuries of the forearm with or without fracture it is wise to decompress the muscles by lateral slits through the deep fascia. It is better to employ elevation and traction until any unusual degree of swelling disappears, than to insist on immediate reduction Hot dressings and diathermy aid in the relief of intrinsic pressure of moderate degree. Immediate

débridement and loose closure or drainage of contaminated muscle injuries prevent deeper infection and the effects of pressure in the deep muscular compartment.

Meyerding has admirably divided the treatment of the established condition into several groups, which can be modified somewhat, as follows

1 When the muscle damage has occurred and has been diagnosed within a few hours by the symptoms described above as the onset, abandonment of the treatment of fracture or incision of the forearm, or both are indicated Relief of minor grades of swelling can be obtained by skilled massage Surface stroking (avoiding the edematous, swollen and painful area at first and gradually encroaching upon it later) is succeeded in a few days by deeper stroking and, finally in the course of weeks, by gentle kneading No such treatment should be followed by pain or discomfort. In the words of Mennell, "A good working law is that if pain can be relieved by massage, all is well" Active exercise in a warm whirlpool bath, followed by gentle massage is indicated for edema resulting from contusion Gentle traction on the fingers by means of a banjo splint or the type of finger extension splint devised by Koch with elevation of the arm, should be employed during the periods when physical therapy is not being applied.

2 When the case is first seen several weeks after the contracture is established incision is probably of little or no value The hematoma or edema has now largely subsided, and fibrosis of the muscles has begun. The relief of congestion and edema by massage and whirlpool bath and active motion is indicated It is a matter for careful decision whether forcible manipulation to stretch the contracting muscle is desirable. After the first few weeks it is unquestionably detrimental. Traction splints with constant extension by means of elastic bands are always of considerable benefit. The traction must be gentle and not productive of pain. At whatever stage the patient comes to the surgeon, the hand should be examined for the signs of ulnar or radial nerve compression and if this is diagnosed, an operation is immediately indicated to free the nerve from cicatrix, a neurolysis being done if necessary

3 The next group consists of patients who present themselves with a deformity of many months duration, in which the fingers can be straightened or at least almost extended with the wrist flexed and where there is no marked degree of stiffening in the joint capsules of the fingers or wrist. Often the hand is cold and may be pulseless, and there are symptoms of nerve involvement. These patients respond less favorably to the Jones treatment of continuous extension and massage and are best operated upon after a course of stretching and massage to restore flexibility of the muscles and increase the blood supply The operation of choice is the Bailey operation of severing

the flexor supinator group and the pronator radii teres close to their origins and transplanting them farther down the forearm The Max Page modification of transplanting the inner condyle, which gives origin to a large number of the fibers of the flexor pronator group to the inner aspect of the ulna offers a larger chance of establishing a firm, bony origin for the shortened muscles Either of these procedures offers less chance of resulting fibrosis than an attempt at tendon lengthening in the wrist or forearm, where the tendons are already anemic and atrophied After from one to two weeks rest on a cock up splint, active physical treatment must be continued to preserve the blood supply of the shortened muscles and prevent fibrosis in the new region of operative injury Elastic traction splinting may need to be resumed Active motion is of prime importance to preserve the neural and vasomotor arc.

4 A last group of old contractures have atrophy of the bones and ankylosed joints as well as atrophy and fibrosis of both flexors and extensors of the wrist and fingers. The fingers cannot be straightened and yield no results from prolonged physical means of treatment. Surgery is definitely indicated here to restore somewhat the normal appearance of the hand which may still retain a slight grasping power or some degree of opposibility of the thumb

Spasm of Voluntary Muscles

There is a large group of cases which appear for treatment with a tendency to spasm of a muscle or muscle group These have been divided into functional and 'reflex' or 'irritative but at a glance it can be seen that in any particular case it is not always easy to decide that the condition is purely functional without a reflex component. There is no doubt that a contracture may begin as a functional or occupational type and later on impairment of the neuromuscular arc or vasomotor arc may occur from disuse of the part According to cause a better grouping suggests itself as

I Muscle habit and occupational.
II Reflex.
 a Without a vasomotor imbalance
 b Accompanied by or the result of vasomotor imbalance.
III Symptomatic of toxic, constitutional nervous disease
IV Hysterical.

The first group may in some individuals be explained by suggestion the habit of contraction being established as the result of a trivial trauma which causes slight pain on motion of a muscle group Any trauma which disturbs the normal mechanism of the muscles may lead to a purely functional disability It is difficult to draw the line between these and cases of purposeful exaggeration of slight symptoms resulting from the desire of the patient to receive com

pensation or to substantiate a claim in common law Apparently, the habit of contraction of a certain muscle or group at first is voluntary but later the patient by autosuggestion, believes that the contraction actually exists, and finally is unable to control the action of the group involved This type of reaction can be described as conscious and unconscious malingering the patient at first realizing that he has no disability, but later being unable to distinguish between feigned and real disability in function This represents one of the most difficult sequels of injury arising in connection with workmen s compensation claims.

The commonest type of occupation spasm is writers' cramp. Any occupation which requires constant use or overuse of a muscle is likely to produce a similar spasm, especially if the muscles engaged in the occupation perform some highly specialized movements which necessitate elaborate coördination Thus, it is not uncommon for writers stenographers and watchmakers to lose the use of their hands from spasm, the muscles commonly affected being the flexor group of the fingers A similar condition is seen in the new military recruits who come from the class of men not accustomed to much walking and who develop marchers' cramp of the feet during the early weeks of military training The pain may be located in the calf muscles or involve the short flexor muscles of the toes. True equinovarus may develop Physical therapy technicians develop a similar cramp in the forearm muscles These various spasms are commonly thought by the patient to be due to a neuritis Children practicing at the piano for long hours manifest a quite similar condition There is always a question of the importance of the psychic element in such a child. It is easy to make a mistake in the diagnosis of spasms about the shoulder by considering these to be primary and due to occupation when they are in reality a reflex attempt for the muscles partially to immobilize an inflamed joint or prevent motions of the shoulder which aggravate a subdeltoid bursitis.

It will be seen, then, that it is not always possible to separate reflex spasm from the first group but in case of the former careful examination should reveal the inflammatory lesion which is responsible for the spasm. Trauma of the muscles may set up a reflex disturbance or it may be the starting point of an hysterical disability or lead to the establishment of a bad muscle habit of imbalance finally resulting in permanent deformity The actual loss of power and sensation due to the primary injury may pass off but the reflex protective contraction of muscles which prevents movement of the injured part may persist, so that at the time of examination no evidence of the original trauma is appreciable. The reflex spasm may or may not be associated with a vasomotor imbalance In either case there may be a disabling pain It is important to know whether this pain is due to pressure on a sensory nerve or not for instance, where it is due to a tender scar on the inner side of the foot whether fibrosis has

involved some sensory terminations which may result in walking on the outer side of the foot with the member held in supination. With the passage of time the pronators and external rotators of the foot become flaccid and the supinators and internal rotators become spastic. Different types of anesthesia may develop If there is an actual nerve lesion the sensory distribution of the skin of the part gives the typical changes in protopathic and epicritic sensation This aids in making a diagnosis as to the nerve involved and the level of the lesion so that a definite indication is established for an operation to free the nerve from fibrosis Partial lesions of the median nerve furnish the commonest example of reflex spasm and result in a serious and disabling type of pain called causalgia. The writer has seen two such spasms affecting the muscles innervated by the ulnar nerve with a painful paresthesia of the small finger and ulnar border of the hand. Anesthesia or hyperesthesia depends upon the extent of the lesion of the nerve.

There is another type in which we find an organic anesthesia, a functional change in the use of the muscles and a loss of skin sensation may persist indefinitely The question always arises here as to whether the disease is due to vasospasm or peripheral nerve injury Ordinarily in case of vasospasm, if this is of sufficiently marked degree atrophic changes finally appear in the skin, and the part becomes blanched or cyanotic depending on whether the lesion is principally venous or arterial. As mentioned before the muscle as well as the skin is affected by these vascular changes, as determined by the experiments of Leriche The anesthesia of vasomotor type does not of course correspond to any nerve distribution. There is likely to be some edema and the skin ultimately may desquamate or there is a loss of the hair and the nails become deformed if the part affected is the hand or foot. The anesthesia in these cases is much like the anesthesia of disuse described by Babinski and Froment Before the importance of the vasomotor tone in these cases was fully appreciated these authors described the above condition as "physiopathic contracture and Siccard called it "acromyotonus." Weir Mitchell writing many years ago had evidently recognized these cases as different from the ordinary muscular spasm without vasomotor involvement which he called "paralysis from peripheral irritation. Every physical therapy technician has noted that, in treating any long-standing injury of an extremity even when spasm or paralysis is not present to any appreciable degree there may be a marked vasomotor disturbance evidenced by excessive sweating in the hand or foot of the limb involved also that this vasomotor disturbance may appear as long as the patient's attention is called to his condition or when he begins to discuss his injury even before heat and massage are applied to the injured part. It is evident, therefore that there is an autonomic imbalance in many injuries of the extremities and this is affected by the mental state of the patient.

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The spasm in these cases, while generally tonic, may also be clonic of a rhythmic or of an irregular type. The commonest form of clonic spasm is probably seen in tibialis posticus, being precipitated by weight bearing on the ball of the foot. Evidently this muscle becomes shortened. There may even be inversion of the foot. The same clonus may be seen in the calf muscles This clonic spasm may be a local condition having no causal element in lesions of the central nervous system Irregular spasm occurs when two antagonistic groups of muscles both manifest reflex spasm the contracture of one set stretching the other, initiating a stretch reflex in the second group. When these conditions are seen in the hand the physician commonly thinks of an hysterical etiology but search for cause may reveal the development of a reflex spasm from injury or nerve irritation.

Symptomatic spasm of muscles may be due to tetany of various types chorea or various diseases of the central nervous system—for instance cerebellar disturbances Parkinson s disease encephalitis lethargica disseminated sclerosis and other diseases causing rigidity of the voluntary muscles. However, these conditions must be diagnosed by many signs and symptoms in addition to spasm of the muscles Moreover the muscular spasm seldom affects one muscle group They are mentioned in the present category because the general indications for treatment, so far as physical therapy is concerned, are quite similar In addition to physical therapy the various etiologic factors, of course deserve therapeutic consideration. In a few instances after cerebellar operations, prolonged physical treatment for the reëstablishment of the normal muscle tone must be undertaken In all this group fatigue of the muscles involved sets in more rapidly than normally and there is actual weakness of the muscles, even though the spasm in the muscles exists

Hysterical spasms and contractures furnish another group of these disabilities although any of the first three groups are capable of becoming hysterical in nature given the proper temperament and provocative "psychic trauma. The greatest difficulty connected with this group is to be certain of the diagnosis and this requires the work of others than physical therapists The symptoms present various unexpected contractures or hysterical attitudes often varying from time to time when examined under varying circumstances. There is never any alteration in the reflex or any vasomotor change in the part other than a slight coldness of the extremity from lack of use. No trophic disturbances are present and no modifications of the electrical reactions of the affected muscles. The striking changes in symptoms, as a result of successful suggestion to the patient, are a notable feature. Restriction of the visual field, the history of bizarre types of convulsions which do not correspond to any organic entity and anesthesias not based on the nerve distribution aid in making the diagnosis

In the cases of the first and second groups numbered I and II muscle atrophy may appear with the relaxation of the opposing

muscles, and the affected muscles may give an exaggerated response to percussion with a hammer The resulting contracture is large in amplitude often delayed in the rise to its height and slower than normal to subside After immersion in a bath of hot paraffin wax, the percussion tests reveal more normal reaction. Electrical responses are never those of the reaction of degeneration. There is an exaggerated response to faradism unless the limb is so cold that skin resistance interferes with the passage of the current. Galvanic current stimulation produces a slow contraction of large amplitude After the affected limb is immersed in hot water or paraffin and retested the muscle responses are more brisk and approach the healthy muscle twitch. The amount of abnormality in response to galvanism probably depends on the proportion of vasomotor disturbances The tendon reflexes may be slightly exaggerated or normal In Group III the deep reflexes of the various nervous diseases depend upon the site of the lesion. The hysterical case is notable for not presenting changed reflexes or altered reactions to faradism or galvanism diagnostic of other muscle conditions.

Treatment.—Every possible method of treatment has been suggested in these cases. Unquestionably the most important factor in their management is first, to exercise to the full extent every muscle in the limb over which the patient retains control. Since the cortical pattern of voluntary movement is not divided into muscles but into movements the patient must be instructed as to what movement is necessary for exercise of the affected muscle and then assisted in performing this exercise until he is able to regain some voluntary control of the spastic muscle Gentle massage of the affected muscle is indicated but only up to the threshold of tenderness Gentle stroking aids in relaxing the spastic muscle preparatory to active or assistive motion First, the application of heat or immersion in hot paraffin wax relaxes at least temporary vasospasm and allows a further motion without pain than that which could be accomplished by the patient if there were no preliminary heating of the part The same applies to gentle massage Surface massage furthermore aids in dissipation of edema where this exists It should be remembered that in all spasms of voluntary muscles the point of fatigue is much lower than in normal muscles and it is of utmost importance in all active motions to keep below the point where fatigue appears or pain develops This entire group of disabilities presents a condition where massage alone is almost certainly doomed to failure and where vigorous or energetic physical treatment of any sort may aggravate the condition One of the greatest difficulties arising in connection with the reference by the surgeon to an unskilled masseur for treatment of this and other affections of muscles is the danger of too robust treatment which is certain to occur in the hands of a physical therapist whose view point is that of a masseur and who has a fixed idea that he can rub

out muscle soreness After active exercise is begun and the patient is convinced that pain on motion, tenderness and spasm are subsiding, he may develop a great enthusiasm for hastening his recovery by strenuous exercise at home between treatments Such a situation is reprehensible, and the physical therapist will not realize the cause of the return of symptoms unless he carefully interrogates the patient as to the exact amount of exercise he takes between treatments. It is advisable to give the patient written instructions, in very specific language, as to the number of minutes of exercise he should take at home and the exact amount of motion or weight-bearing he should perform each day and to be certain that he follows this régime punctiliously Nothing is accomplished by attempting to hasten recovery of these patients Any return of pain or spasm necessitates the resumption of the primary stages of treatment, consisting of baking and the gentlest massage after which active motion can be again gradually resumed

Occupational spasms, like writers cramp, often require immobilization of the part on a splint, with no treatment except baking or diathermy until the weakness, tremor and lack of coördination have begun to subside. Later the gentlest surface massage from wrist to shoulder can be applied for a few minutes a day Mennell places great importance on the rhythmic element in massage of such an extremity, probably with the idea that each passage of the masseur's hand stimulates the rhythmic stretch reflex response and helps in the restoration of the normal coördination of muscular action. He also believes that exercise for the shoulder and elbow should be rhythmic in type often using at first a swinging motion and later on adding pulley and roller exercises always keeping below the point of exciting the spasm. In the management of the patient with writers cramp all motions can be performed except those of actual writing Later, when writing can be performed without pain or spasm large letters should be written on a blackboard and, as the improvement continues, the size of the letters can be reduced until the ordinary handwriting is reproduced The patient should be studied to see whether he uses the full arm movement in writing or only the finger movement If the cramp has been produced by finger movement writing, he should be taught to write by the full-arm method

The treatment of reflex spasm is not satisfactory unless a definite cause can be found and removed A painful scar or sensory nerve irritation demands surgical treatment before reëducation can be started The psychic element is sometimes important. When the patient s confidence is gained and he realizes that the pain and spasm are diminishing recovery is tremendously expedited Diathermy will help in dissipating vasospasm after proper surgery has been employed. There is a serious question whether routine faradic stimulation has any more effect in reestablishing vasomotor tone or in retaining the neuromuscular arc than massage to stimulate the stretch reflexes and

active motion to retrain the nervous arc in coördination of muscles The paraffin bath is particularly valuable in the type accompanied by vasomotor disturbances Sometimes the patient must be investigated for allergic phenomena and an effort made to desensitize him to the offending substance Reeducation of muscle coordination should begin early in these cases

It is often important not to treat the spastic part at all in the management of the hysterical case and to pay no attention to the patient s complaints The prescription of general exercise, after explaining to the patient that you realize there is no organic basis for his disability may yield a better result than too much attention to the affected part. The management of the psychic features is outside the function of this discussion. Fortunately the settlement of a patient s claim for damages in an injury case is only effective in treatment of the spasm of muscles before the case has actually become hysterical and while he still realizes that he is feigning the condition After a stage of hysteria is established when the patient can no longer realize that the condition is not feigned one striking method of reestablishing his mental control of the situation is the production of full movement of the contracted part under anesthesia and the splinting of the part in the position of full movement so that he realizes after awakening that such motion can be performed and painlessly I have had striking results with the relief of hysterical spasm of the masseter muscles by this method.

Spastic Paralysis

Cases of chronic spastic paralysis of the voluntary muscles where contractions and flexion deformities are already established whether from vascular lesions of the cortex or pyramidal tracts or arrested development of upper motor neurones or their connecting links in the brain stem or cord present some of the most disheartening conditions the physical therapist is called upon to treat Without the coöperation of the surgeon and physical therapist the patient is certain to pass from bad to worse At almost any stage of spastic paralysis the combined efforts of the two however will be rewarded by some improvement

It is important to remember that in the motor cortex of the cerebrum individual muscle actions are not represented but the movement of the part is represented. This movement pattern includes both the protagonists for any motion and synergists and the antagonists and the fixing muscles This is the law of reciprocal innervation and its implication so far as treatment is concerned is that, in retraining voluntary motion after spastic paralysis we are retraining all these components of the motion In brief we are not training the man to contract any muscle but to perform a coördinated motion. Stored in the parietal lobe are too the memories of various move-

ment patterns which the patient has carried out before disease interfered with their performance, and these memories must be revived before the voluntary movement can be repeated. Furthermore, voluntary movement of the unaffected extremity may help in reestablishing the memory of the act on the opposite side. Assistive movements may help to revive this memory, which is of necessity the first step in rehabilitation (See Vol II)

For purposes of treatment, the types of spastic paralysis can be divided into four groups

1 Vascular lesions—hemorrhage, thrombosis embolism obliterations, new growths involving the pyramidal system anywhere in its course These tracts may be compressed in the spinal cord from without or by a distention from within as in the case of syringomyelia

2 Lack of development or arrested development in the cortex—the spastic diplegia of infants or Little's disease Gradual death of the cells of the cortex produces spastic paralysis and an amyotrophic lateral sclerosis Paresis of syphilitic origin affects the cerebral cortex

3 In combined degeneration and in disseminated sclerosis, the medullary sheaths of the pyramidal fibers are destroyed.

4 Lesions in or near the corpus striatum produce Parkinson's paralysis agitans and similar conditions following encephalitis lethargica and progressive lenticular degeneration.

The management of hemiplegia as far as its physical treatment is concerned can be divided into stages It is customary to say that all symptoms are present on the opposite side of the body from the lesion It can be laid down as a general rule that, if any great catastrophe occurs in the central nervous system, function is disturbed even in regions remote from the structures involved During the first few hours we find the muscles on the opposite side from the lesion flaccid and toneless with their deep reflexes lost. Certain regions are practically unaffected e g muscles of the eyes chest and abdomen The paralysis then involves only the opposite arm leg or face and spares such muscles as those of the eye which act bilaterally so that movement of the eyeballs and emotional expression are preserved When this initial stage of shock subsides spasm is found to exist in all muscles of the affected extremity but with a difference in tone between the antigravity and the gravity muscles—in other words since tone is concerned principally in maintenance of position or posture the muscles involved in maintaining the erect position in man are principally affected The affected parts tend to assume the position of decerebrate rigidity described earlier in this article The upper limb is adducted at the shoulder the elbow semiflexed with the forearm pronated and the wrist and fingers flexed These motions represent the movements of the [illegible] It is the first duty in physical treatment to prev[illegible] contraction deformities It is important to [illegible] position

for the various muscle groups so that there is some deviation from the midposition of the joint toward the weaker group of muscles. This means for instance an abduction of the shoulder to protect the weak abductors and external rotators against the stronger adductors and internal rotators the splinting of the elbow in extension or slight flexion at the midposition between pronation and supination, or with a little inclination toward supination because supination is normally stronger than pronation We have now accomplished the first step toward protecting the weaker muscles by establishing muscle balance and in the prevention of deformity The position of decerebrate rigidity in the lower extremity leaves the foot plantar flexed at the ankle with the toes flexed and sometimes with supination. These positions are corrected in the same manner

After this primary consideration the patient must be made to understand that the return of movement cannot be brought about by massage or electrical treatment but by his own effort. One seldom sees a case in which some of the motor fibers are not preserved and the management of the case contemplates preserving this minimum of muscle action and prevention of fibrosis of muscle which occurs in muscle during disuse The patient must not lie continually in bed with his arms folded across his chest. If there is inability to perform simultaneously the various motions that constitute an act, because of the so-called decomposition of movements, some slight individual movements may be retained and these slight voluntary movements with the assistance of the operator should be performed several times each day but not to the point of fatigue. It is important that the patient make a mental effort to reproduce the motions each time treatment is given The appearance of each new movement will be welcomed and the patient s interest stimulated and his coöperation assured. The motions of the opposite extremity aid in the motion of the affected extremity Rhythmic motion to music or by numbers prevents an excess of effort when the motion is performed. The reëstablishment of movement patterns in the brain *may sometimes* be stimulated by the application of faradic current of the sine wave form as by minimum stimulation with a Smart Bristow coil After the returning movement is called to the patient s attention by this means voluntary movement can be accomplished. Further than this electrical stimulation has little or no place in the treatment of spastic paralysis It is very easy to overstimulate a muscle with electricity and cause injurious fatigue which results in more fibrosis than if no treatment had been undertaken The patient requires special advice when he begins to walk His natural inclination is to walk in the easiest fashion by advancing the legs by circumduction, neglecting to flex the hips or knees and with the foot pronated and everted The patient should be taught to walk slightly pigeon toed and to lift the leg with each step even if this can be accomplished only through a few degrees of motion

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The management of hemiplegia, as far as its physical treatment is concerned can be divided into stages. It is customary to say that all symptoms are present on the opposite side of the body from the brain lesion. It can be laid down as a general rule that, if any great catastrophe occurs in the central nervous system function is disturbed even in regions remote from the structures involved. During the first few hours we find the muscles on the opposite side from the lesion flaccid and toneless with their deep reflexes lost. Certain regions are practically unaffected e g. muscles of the eyes chest and abdomen. The paralysis then involves only the opposite arm leg or face and spares such muscles as those of the eye which act bilaterally so that movement of the eyeballs and emotional expression are preserved. When this initial stage of shock subsides spasm is found to exist in all muscles of the affected extremity but with a difference in tone between the antigravity and the gravity muscles—in other words, since tone is concerned principally in maintenance of position or posture the muscles involved in maintaining the erect position in man are principally affected The affected parts tend to assume the position of decerebrate rigidity described earlier in this article. The upper limb is adducted at the shoulder the elbow semiflexed with the forearm pronated and the wrist and fingers flexed These motions represent the movements of the stronger muscles and it is the first duty in physical treatment to prevent these typical contraction deformities. It is important to splint the affected limbs in zero position

for the various muscle groups so that there is some deviation from the midposition of the joint toward the weaker group of muscles. This means for instance an abduction of the shoulder to protect the weak abductors and external rotators against the stronger adductors and internal rotators the splinting of the elbow in extension or slight flexion at the midposition between pronation and supination or with a little inclination toward supination because supination is normally stronger than pronation. We have now accomplished the first step toward protecting the weaker muscles by establishing muscle balance and in the prevention of deformity The position of decerebrate rigidity in the lower extremity leaves the foot plantar flexed at the ankle with the toes flexed and sometimes with supination These positions are corrected in the same manner

After this primary consideration the patient must be made to understand that the return of movement cannot be brought about by massage or electrical treatment, but by his own effort. One seldom sees a case in which some of the motor fibers are not preserved and the management of the case contemplates preserving this minimum of muscle action and prevention of fibrosis of muscle which occurs in muscle during disuse The patient must not lie continually in bed with his arms folded across his chest. If there is inability to perform simultaneously the various motions that constitute an act, because of the so-called decomposition of movements some slight individual movements may be retained and these slight voluntary movements with the assistance of the operator should be performed several times each day but not to the point of fatigue. It is important that the patient make a mental effort to reproduce the motions each time treatment is given The appearance of each new movement will be welcomed and the patient's interest stimulated and his coöperation assured. The motions of the opposite extremity aid in the motion of the affected extremity Rhythmic motion to music or by numbers prevents an excess of effort when the motion is performed. The reëstablishment of movement patterns in the brain may sometimes be stimulated by the application of faradic current of the sine wave form as by minimum stimulation with a Smart Bristow coil After the returning movement is called to the patient s attention by this means voluntary movement can be accomplished Further than this electrical stimulation has little or no place in the treatment of spastic paralysis. It is very easy to overstimulate a muscle with electricity and cause injurious fatigue which results in more fibrosis than if no treatment had been undertaken The patient requires special advice when he begins to walk. His natural inclination is to walk in the easiest fashion by advancing the legs by circumduction neglecting to flex the hips or knees and with the foot pronated and everted The patient should be taught to walk slightly pigeon toed and to lift the leg with each step even if this can be accomplished only through a few degrees of motion

ment-patterns which the patient has carried out before disease interfered with their performance, and these memories must be revived before the voluntary movement can be repeated Furthermore, voluntary movement of the unaffected extremity may help in reëstablishing the memory of the act on the opposite side. Assistive movement may help to revive this memory, which is of necessity the first step in rehabilitation (See Vol II)

For purposes of treatment, the types of spastic paralysis can be divided into four groups

1 Vascular lesions—hemorrhage, thrombosis, embolism, inflammations, new growths involving the pyramidal system anywhere in its course These tracts may be compressed in the spinal cord from without or by a distention from within as in the case of syringomyelia.

2 Lack of development or arrested development in the cortex—the spastic diplegia of infants, or Little s disease Gradual death of Betz cells of the cortex produces spastic paralysis and an amyotrophic lateral sclerosis. Paresis of syphilitic origin affects the cerebral cortex.

3 In combined degeneration and in disseminated sclerosis, the medullary sheaths of the pyramidal fibers are destroyed

4. Lesions in or near the corpus striatum produce Parkinson's paralysis agitans and similar conditions following encephalitis lethargica and progressive lenticular degeneration.

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joints The normal muscle is already possessed of the two properties of contraction and relaxation Relaxation immediately affects the paralyzed group and its antagonists immediately begin to contract. Rest of a paralyzed muscle means both rest from its function of contraction and rest from its function of relaxing which may result from contraction of its opponents. The position of muscle rest has already been described as being that position from which the reëstablishment of function is most easily begun Rest is most suitably accomplished by splinting the splint being frequently removed to see that no damage is done over bony points and that no constriction of the blood supply to the damaged muscle has occurred In the

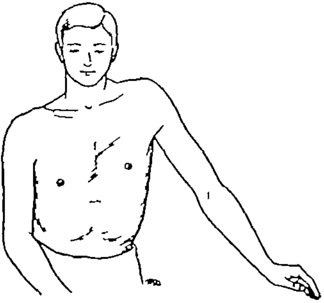

FIG. 4—Wrong position for beginning voluntary movement of partially paralyzed deltoid. Gravity is too strong t allow any initiation f movement in the damaged muscle

mind of every untrained masseur is the delusion that massage can restore size and strength to the damaged muscle This is absolutely untrue No amount of massage can restore muscle power or contour The only effect possible is stimulation of the stretch reflex if a part of this has not been destroyed Violent massage to the muscle belly now deprived of its nerve supply and in some cases with the vasomotor control damaged can only result in further insult to the blood supply in the production of edema and later round cell infiltration In the early stage these flaccid muscles are undergoing degeneration Heat or the alternation of heat and cold may arouse some vasomotor response and keep the tone of the blood vessels intact Stagnation of circulation should be prevented in some cases by elevation of the part. After a varying time which cannot be particularized in general discussion tests should be made to ascertain th, residuum of nervous

When the patient is seen with contracture deformities already developed the surgeon must be consulted in the management of the joints which is covered in another chapter If muscle-tendon groups must be lengthened, the present tendency is toward multiple incisions in the muscle at its junction with the tendon rather than tendon lengthening operations This is called myotomy, and has the advantage of leaving a muscle-tendon system ready for immediate massage and active motion without the necessity of a splinting procedure to hold the part immobile until union of the repaired tendon has occurred.

In Little s disease, reeducation of the muscles is accomplished by routine gymnastic exercises where the patient follows symmetrical motions of the extremities, performed synchronously with both arms or both legs These exercises should be done slowly There is no advantage but many disadvantages, in tiring the muscles or the neuromuscular control The importance of so-called "spaced exercises, with plenty of time for rest between, has been emphasized by Sir Robert Jones

In disseminated sclerosis and other forms of muscular atrophy which are generally classed as progressive, many cases can be improved from progression and the symptoms arrested or retarded. In the early stages massage muscle training and exercises may effect an apparent cure. Even if the further effects of the disease later develop a part of the strength of the muscle fibers has been maintained and at least the opposers and synergists of the most affected muscles can be protected from the atrophy of disuse. Massage in these cases aims at maintenance of nutrition and assistance in performance of exercises Fatigue must absolutely be avoided The patient must be improved after each treatment, or the treatment is detrimental. The same applies to Parkinson s disease especially the type occurring after encephalitis

Flaccid Paralysis

The treatment of the muscles in flaccid paralysis can be divided for clinical purposes into (1) flaccid paralysis of nontraumatic nerve lesion and (2) the flaccid paralysis resulting from complete or partial peripheral nerve section. In the first group it is seldom that the entire nervous control of the muscle is destroyed, and all treatment aims, in the first stages to accomplish effective rest of the muscle, pending the time when suitable tests can be made to find what residual nervous control remains After this initial stage of treatment attempt is made to preserve the function of these neuromuscular arcs which remain and to develop whatever residual nervous control has escaped the damage of the nerve lesion Effective rest of the muscles should begin immediately at the time the paralysis develops. This will minimize the necessity for operative interference or leave the limb in the best possible condition for whatever operation may be necessary, whether this be transplantation of tendons or stabilizing operations on the

Bristow coil, may reëducate the voluntary cerebral control so that the patient is soon able to produce this slight muscle movement himself Passive movement through a part of the arc of the motion to be reëstablished may aid in eliciting the memory of the motion. Massage is now available to relax the opposers prior to each treatment. The active treatment, however consists of training the patient

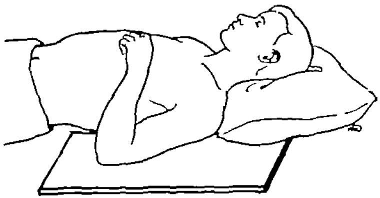

FIG. 6—Position for beginning voluntary motion f paralyzed deltoid.

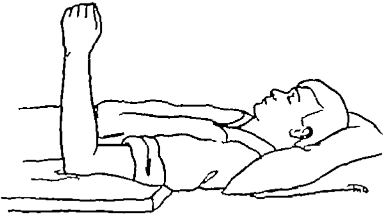

FIG. 7—Commencing voluntary pronation. F rearm has the minimum resistance of weight in this balanced position.

in voluntary motion Such massage should be slow and even the stroking firm and combined with gradual stretching of the contracted antagonists Little massage is necessary over the flaccid muscle Passive manipulation of the joint prevents contraction until the patient learns to use the paralyzed part. No flaccid paralyzed muscle should ever be allowed to stretch by passive motion of the joint. One treatment involving thorough stretching of such a damaged muscle means that the whole task of retraining must be started over again Another warning should be given against overfatigue. If the patient can move

control *There is only one true test for muscular action and that is the volitional test* We must consider the effect of gravity in interfering with the slight motion of a weakened muscle To obviate the weight of the part, it could be suspended in water and the amount of muscle regeneration tested by having the patient move the extremity, which now with the patient in the bath, has no weight, being of the same specific gravity approximately as the water bath. Another method is to begin motion from the most advantageous position with the part lying on a smooth surface—for instance, cardboard to which talcum has been applied One example will illustrate the principle the paralyzed quadriceps femoris group in a child with anterior poliomyelitis, after the infective stage of the disease is past,

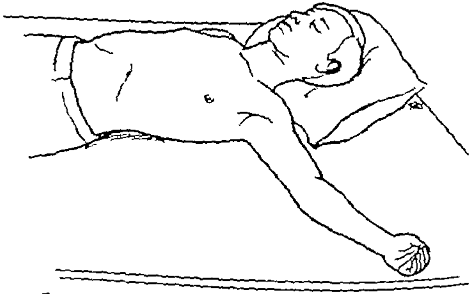

FIG. 5.—Patient able to abduct arm when force of gravity is relieved.

the child, sitting in a chair may not be able to raise the knee because gravity is too strong for the initiation of movement in this damaged muscle group However the child lying down, the knee and hip already being in the position of semiflexion a slight further flexion of the hip can be produced voluntarily This applies equally well to the shoulder muscles and muscles of the arm. Should contraction of the antagonistic uninjured muscles have been allowed to occur through neglect of treatment of the first stage even this test may show no muscle action, although a slight voluntary control still exists. After massage and stretching of the unaffected opposers a slight muscle action of the quadriceps may be found to remain. To my mind the only use of electricity indicated is to aid in restoring the memory of voluntary action of a muscle too far damaged to present any evidence of nervous control with the above tests Often small doses of faradic electricity of the sine type produced with the Smart

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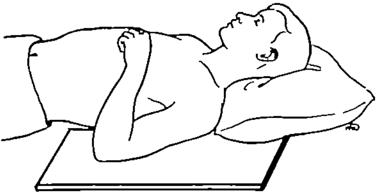

FIG. 6 —Position for beginning voluntary motion of paralyzed deltoid.

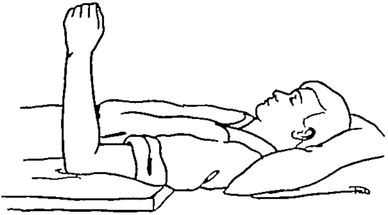

FIG. 7 —Commencing voluntary pronation. Forearm has the minimum resistance of weight in this balanced position.

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the muscle in spaced exercises, only five or six actions of the injured muscle should be attempted in four or five treatments during each day. This is more valuable than pushing the return of motion by more violent action. If on any given day, it is found that exercise cannot be performed with as much freedom as on the day previous, the treatment is being pushed too energetically, and the muscles should be maintained at rest by splinting for two or three days. Then the exercises can be gradually resumed.

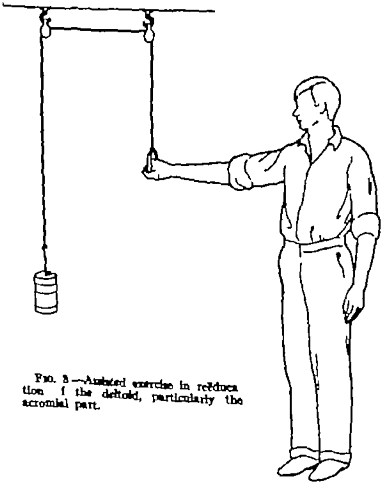


Fig. 8.—Assisted exercise in reëducation of the deltoid, particularly the acromial part.

It is not important for our purpose to distinguish between various types of flaccid paralysis due to disseminated changes in the central nervous system and so-called primary diseases of the muscle like myasthenia gravis which are progressive and may be called flaccid types of paralysis. In all these conditions the tone and strength of the unaffected muscle must be maintained, deformity must be prevented and in some the slow deterioration of the muscles affected may be delayed by the minimum amount of active exercises of the muscle group, also keeping below the threshold of fatigue.

As strength returns in a muscle through training *assistive exercises* may be employed the operator bearing most of the weight of the part—that is, allowing motion with the minimum of effort on the part of the patient. Assistive exercises with weights and pulleys are also serviceable Retraining in walking is covered in a separate article in this system (Molander Vol. III)

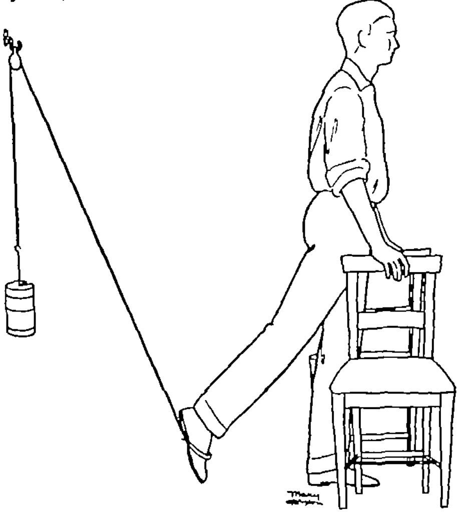


FIG. 9—Earliest resistive exercise of the weakened quadriceps femoris group. This is the same position as employed for assistive exercise of the flexors of the hip.

Paralysis from Severed Nerves.—If the nerve is only partly severed treatment is not so different from that described for flaccid paralysis in central nervous lesions When the nerve is completely severed early massage is indicated to minimize the scar tissue of the original injury which may involve the muscle as well as the nerve When the patient attempts to move the part, many unusual antagonistic movements may result as the impulse is not directed to the

movement of the muscle but to the performance of the motion. While the part is splinted during the treatment of the laceration itself or the treatment of infection gentle massage may preserve the vasomotor tone of the flaccid muscles and as no faradic response is elicited, the sine current of galvanism may aid in preserving the vasomotor reflexes if these do not all reach the muscle along with the severed nerve If a nerve is severed near the shoulder or hip, a part of the

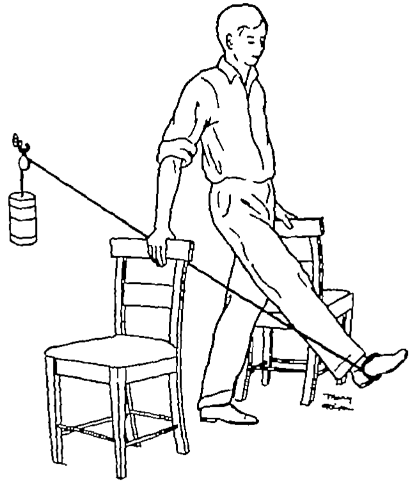


FIG. 10.—Later position in treatment of weakened extensors of the knee and flexors of the hip

vasomotor reflex reaches the affected muscle from the autonomic fibers traveling along the main arteries of the part while others travel in the same sheath with the injured peripheral nerve.

After surgical repair of the severed nerve if the operation is successful faradic response gradually appears in the muscle Faradic treatment has as its only importance reëducation of the voluntary control of the muscle It is easy to overdo this faradic stimulation. Only a few contractions of the muscles daily by this method should

be attempted After the habit pattern is reëstablished in the brain, the patient is able voluntarily to perform a minimum of motion under the type of management just described for the flaccid paralysis of central nervous diseases

In a recapitulation of this subject, Mennell has laid down certain principles which are briefly as follows

1 An enfeebled muscle cannot contract unless and until its antagonist relaxes in conformity

2 To make sure that the patient's muscles know how to perform the movement the sound limb should be put through the same movement which we expect to reeducate in the injured extremity

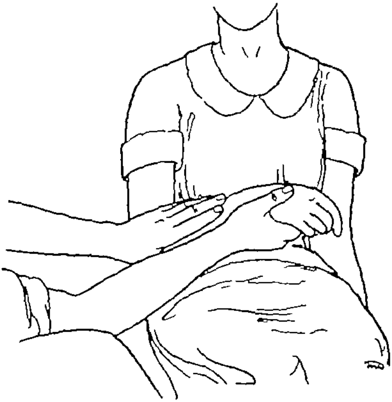


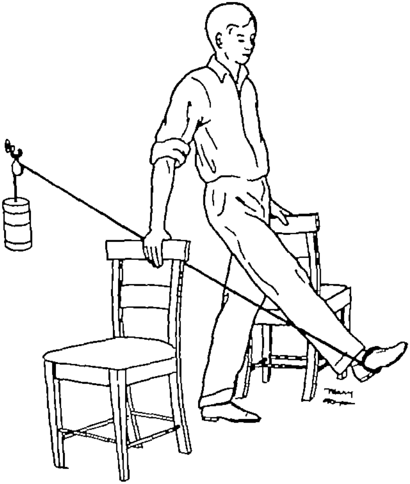
FIG. 11 —Position for manually assisted supination.

3 In muscle reeducation we must not set a task for the muscle more difficult than it can perform at any given stage in regeneration.

4 As one type of motion is accomplished a second should be devised each entailing imperceptibly greater coördination than the previous one

5 Mackenzie has pointed out that it is best to begin with retraining of the specific functions of each muscle and to add concerted

movement of the muscle but to the performance of the motion. While the part is splinted during the treatment of the laceration itself or the treatment of infection gentle massage may preserve the vasomotor tone of the flaccid muscles and, as no faradic response is elicited, the sine current of galvanism may aid in preserving the vasomotor reflexes if these do not all reach the muscle along with the severed nerve. If a nerve is severed near the shoulder or hip, a part of the



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actions later He believes that each muscle normally has one specific action.

6 Submaximal effort should be repeated frequently a few times a day and the maximum effort less frequently if at all

7 The enfeebled muscle must never be stretched

8 If on any day the patient is found not able to perform as much motion as on the previous day, the task should be lightened for a few days

9 An atrophy from disuse is as hard or harder to cure than atrophy from disease Nothing must be done which interferes with the blood supply or delays the venous drainage of the part.

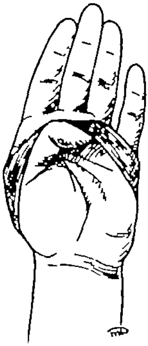

Fig 14—Application of adhesive strap to protect paralyzed flexor system of thumb (median paralysis)

Inflammations of Muscles

Myalgia (Muscular Rheumatism)—This term refers practically to all cases of inflammations of the muscles and their attachments with the accompanying spasm and pain on motion. The treatment of this affection of the muscles in its acute stage is familiar to all physicians engaged in physical treatment and is more thoroughly covered in the volume of this series devoted to internal medicine The treatment of acute rheumatic affections is in a large part, constitutional the physical means applied to the affected muscles being only palliative Hydrotherapy for the purpose of stimulating the blood

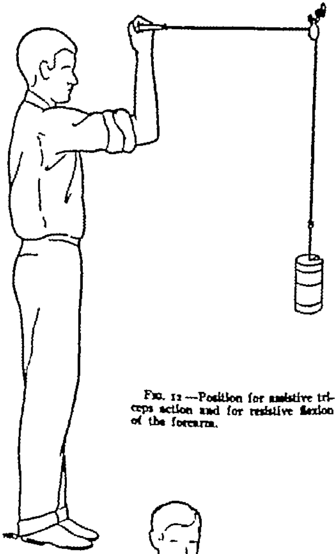

Fig. 12.—Position for assistive triceps action and for resistive flexion of the forearm.

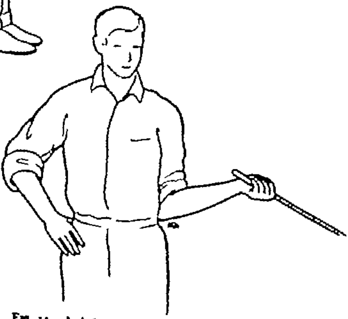

Fig. 13.—Assistive supination by means of weight (a poker)

actions later He believes that each muscle normally has one specific action

6 Submaximal effort should be repeated frequently a few times a day and the maximum effort less frequently if at all.

7 The enfeebled muscle must never be stretched

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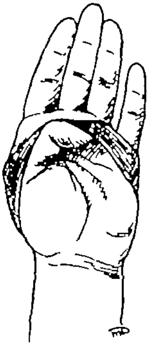

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supply, and the use of various baking apparatus need no description here.

Pemberton thinks that the physiologic background of the problem of derangement of muscle function in these affections probably has to do with an alteration in the "finer blood supply" Microscopic study of the capillary beds shows various irregularities with decrease

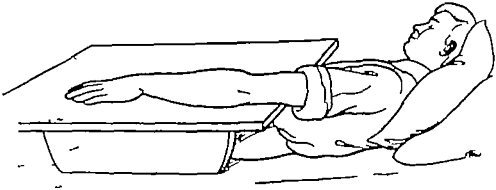

FIG. 5.—Position for beginning of active flexion of the elbow

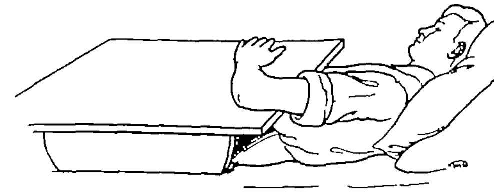

FIG. 6—The starting position of active extension of the elbow This also represents the position of the completion of the movement initiated in Figure 15.

in the blood content and flow He finds that the capillary bed is rather immobile and in a state resembling vasoconstriction and responds inadequately to stimulation The physiology of the treatment of acute muscular rheumatism, then involves the vasomotor tone of the smaller arterioles venules and capillaries The restoration of vasomotor control has been previously described in this article, and the same methods are applicable here as elsewhere when their derangement is manifest.

Chronic myositis, or as aptly described by Albee "myofascitis," is an entirely different problem Here two important pathologic processes are present besides the changes in the blood supply formerly described The first of these is the tendency toward fibrosis, which results from the fibrositis of the muscle reticulum the other is the

development of specific deposits in the muscle often near its tendon attachment. These deposits can be felt on palpation of the patient s muscles. These nodes are capable of causing considerable pain on motion and often correspond to the definitely localized tender areas of chronic myositis. They correspond pathologically in the main to Aschoff's nodes which are peculiar to rheumatic infections.

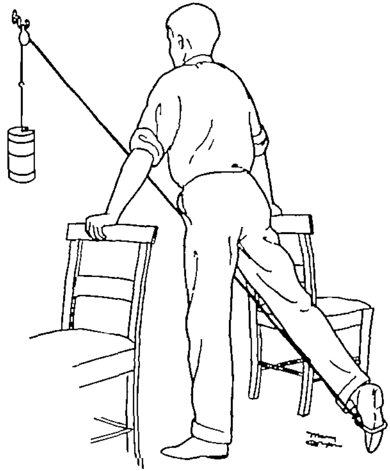

FIG. 17—To show resistive exercise to the extensors f the hip

One of the notable features of the symptomatology of chronic myositis is that whereas the muscle is generally painful and tender on motion during acute myositis, when the acuity subsides the patient will still complain of exquisite tenderness on motion while, as a matter of fact the pain on motion only exists if this movement causes com pression of one of the nodes or areas of induration just described The sufferer is apprehensive of all motion and although the acute process in the muscle has long since burned itself out, the feeling of constriction persists due to fibrositis in the affected muscles and he interprets this as pain. After the joints have once been forcibly

moved, he realizes that a large amount of motion of the joints and muscles is possible without the excruciating pain that he once experienced during the acute stage. This psychologic phenomenon is probably the basis of the many remarkable cures effected by unskilled bone setters and irregular practitioners of medicine who forcibly

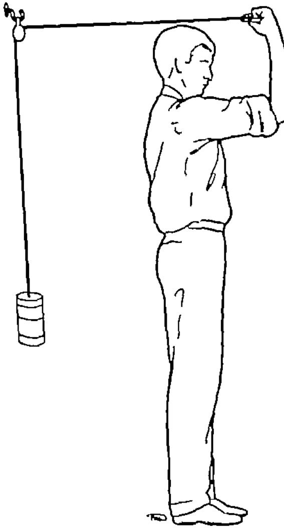

FIG. 18.—To illustrate resistive exercise for the brachialis anticus. (The biceps takes part in this action when forearm is in supination.)

manipulate the joints and muscles, liberating the muscle parenchyma from any fibrous deposits and restoring motion in a miraculously short time. In chronic myositis when the possibility of gonorrheal or tuberculous infection of the nearby joints is eliminated, forcible manipulation under anesthesia in graded doses often aids greatly in expediting the return of function. Before each such manipulation, however, baking, massage and passive motions up to the threshold of pain

should be repeatedly performed After the forcible treatment baking massage and passive motions must be resumed immediately to prevent the production of more disabling fibrous bands in the muscles

There is no question but that baking and massage aid tremendously in the dissipation of the nodes just mentioned. Treatment of these nodes is an important part of the physical treatment of chronic myositis. Radcliffe recommends special massage with deep thumbing movements about and under the deposits always accompanied by kneading to stretch the adhesions and render these deposits more mobile This is of course in addition to the general massage of the entire muscle involved. Marlin has applied galvanic current directly to the tender node a needle attached to the negative pole being inserted and a current of five milliamperes being exhibited for three to six minutes This of course, must be accompanied by specific massage of the tender areas

Some of the typical forms of chronic myositis can be mentioned Very often on examination a few affected muscles can be picked out Commonly the latissimus dorsi the serratus magnus the pectorals the long muscles of the back and the muscles of the calf and thigh present a definite increase in consistency to the palpating finger and tenderness is elicited on palpation in the areas of greatest stiffness An old trick used by osteopaths is to examine a man s back and tell him before he has pointed it out to the examiner exactly where the pain exists This is easy to do under careful palpation with the examined muscles in a relaxed condition. The tender spot corresponds to an area of muscle spasm.

Lumbago —Lumbago may be described as a typical form of chronic inflammation of muscles although the fascia and fascial attachment and tendons of the back may or may not be also involved in the process Early massage can frequently prevent full development of an attack Generally baking followed by deep massage, will relieve the local condition This treatment, however is symptomatic. The original focus of infection or intoxication somewhere in the body if such an etiologic factor exists must, of course be corrected Careful diagnosis of the back case must be made to eliminate joint inflamma tions and protective spasm to relieve faulty joint relationships must be ruled out before a case can be considered as a simple muscular lumbago In treatment by massage after suitable heat has been applied to relax the muscles surface stroking over the long muscles of the back from the sacrum toward the dorsal region is followed after a few moments by deeper massage with the ball of the thumb expressing blood from the muscles with each motion It is generally necessary to treat the long muscles of the back well out from the region of spasm and pain extending for instance if the complaint is pain in the upper lumbar muscles low down over the sacrum and up over the muscles of the dorsal spine Deep vibrations with electric vibrators aid in

establishing the circulation in the deeper muscles—for instance the quadratus lumborum.

Stiff Neck or Rheumatic Torticollis.—This is quite similar in therapeutics to lumbago After the application of heat, stroking should be applied over the entire course of the sternocleidomastoid and other muscles involved followed by deeper kneading movements. Occasionally a chronic case is benefited by forcible manipulation, limited

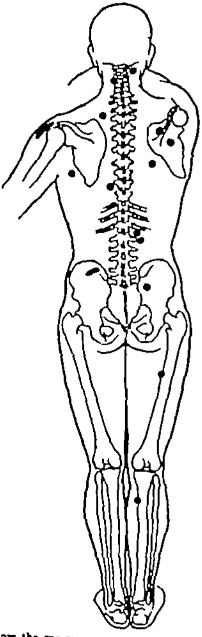

Fig. 10.—Diagram to show the commonest situations of sensitive deposits. (After James Mennell in Backache Phila., P Blakiston's Son and Co Inc., 1931)

in extent of motion and preceded and followed by the usual physical treatment.

When the chronic muscle pathology is generalized and after the acuity has disappeared gentle general exercises and massage are valuable Shoulder circling increases the blood supply to all the upper muscles of the arm, and wrist and elbow exercises have a similar effect upon the lower muscles of this extremity Trunk exercises are beneficial to restore circulation and relieve fibrosis in the chest, abdominal and back muscles It is important to reëstablish full motion of all the muscles of the lower extremities before the various powerful fascial compartments have become shrunken from fibrosis and mechanically interfere with muscle movement.

Physical Treatment After Tendon Operations

Intelligent management of a case after a tendon operation has been performed depends upon a comprehensive knowledge of exactly what

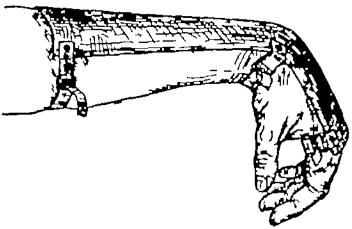

Fig. 10—Method of splinting hand after a repair of the flexor tendons so as to allow early movement of the tendons The muscles cannot pull strongly enough to break the tendon sutures as the splint holds them in relaxation. (From Lewis, Practice of Surgery Hagerstown, Md., W F Prior Co Inc., 1931)

was done at the operation and the result which is expected from the operative interference If repair or plastic operation of the tendon has been surgically correct, and adequate fixation sutures have been introduced to make the tendon mechanically sound physical treatment can be begun immediately after the operation and even before the skin sutures have been removed in fact it is preferable to splinting a case for several weeks until the tendon heals and then expecting to overcome the fibrosis which occurs around the tendon after this condition is thoroughly established If the physical therapist is in doubt as to the tensile strength of the tendon repair it is necessary to allow a period of several weeks for the repair to become firm before any

movement of the nearby joints can be instituted In the latter case, heat and massage can be applied to restore the normal circulation in the part from the beginning of the treatment, even before the tendon is firmly united The operations upon tendons can be divided into tenotomy tendon lengthening, fixation of a luxated tendon, transplantation repair of lacerations and freeing adherent tendons.

Tenotomy —This is done to correct a deformity and relieve the pull of an over-contracted or shortened muscle If the operation is done subcutaneously so that only a tiny skin puncture remains, massage and manipulation up to the point of pain to reëstablish the proper joint position after the causal factor of tendon shortening has been removed can be immediately instituted The correction of joint deformity is the first objective in treatment. The second objective is strengthening of the weakened opposers, whose action has now been freed by cutting the spastic or contracted antagonists The gradual restoration of joint function by manipulation of the joint through a range of motion up to the point of pain is generally preferable to forcible restoration The patient must be trained to resume the function of the stretched muscles Faradic current aids in retraining this lost muscle action. If an open operation has been done for tenotomy it is important to prevent fibrosis in the operative scar by heat and massage and if there is any keloid tendency by the application of a quartz light or minimum doses of x ray Tenotomies are often done about the feet to correct various talipes deformities. In this case wrenching of the foot forcibly to correct the deformed joint position is done at the time of the operation and whenever swelling and edema result these demand immediate physical treatment from the day of operation The foot should be elevated and the baker applied several times a day accompanied by light stroking massage toward the body to encourage venous and lymphatic return There is a curious fact connected with the distinction between tenotomies about the hand and of the foot After tenotomy for a pes cavus or for destruction of the contracted tendons in a hammer toe mobilization should begin as soon as possible as all divided tendons about the foot tend to reunite unless every effort is made to prevent this In tenotomies of the hand or wrist, however union is quite slow and there is no difficulty in preventing the tendon from growing together Every active or passive motion employed in physical treatment should be one which tends to pull the separated ends farther apart.

Tendon Lengthening —In tenotomy with the exception of the Achilles tendon which under favorable circumstances will regenerate the tendon is sacrificed whereas in tendon lengthening, the function of the revised muscle-tendon system can be preserved A typical indication for the employment of tendon lengthening is in contraction of the muscles of the forearm, and an important consideration in

the physical management of these cases is that the operation be performed not in the free part of the tendon which has no blood supply through a mesotenon but in the muscle at its junction with the tendon as this latter wound will heal readily and allow the immediate institution of physical methods of treatment after the operation is performed. If the delicate tendons of the hand are lengthened in or distal to the wrist no blood supply comes into the tendon through its mesentery the mesotenon and one must allow several weeks to elapse in order to insure a firm tendon union before manipulation of the nearby joints and active motion can be instituted. This is often a calamity and when treatment is finally begun it is found that firm adhesions already bind the tendon in its sheath and only a part of the expected function can be reëstablished Thus, it is not advisable to perform a tendon lengthening in a finger or where the tendon is covered by a sheath, but this should be done above and where the tendon passes through a paratenon as in the forearm or above the ankle Muscle stripping as mentioned previously in connection with the operation of Baily in ischemic paralysis is often more successful than operations on the tendon or at the junction of the muscle and tendon as the region of the muscle where the stripping is done (at its origin) is much more thoroughly supplied with blood than is the tendon.

Tendon Fixation.—If proper muscular balance cannot be restored after the paralysis of certain muscles or muscle groups by tendon transplantations a fixation operation is of definite value This operation consists of dividing the paralyzed muscle at its junction with the tendon and reuniting this divided tendon to the bone which furnishes a check on the antagonistic muscles Occasionally a strip of fascia is used for the same purpose in stabilizing a joint and preventing the antagonist of a paralyzed muscle from pulling a joint into a position of deformity These tendons anchored to the bone are ordinarily passed through a hole bored through the osseous structure and require the ordinary time of three or four weeks for firm attachment to develop Some strain on this new tendon preparation seems necessary to stimulate firm union Such strain can be produced by very gently stretching a revised tendon at the time when massage and gradual stretching of the contracted antagonists are being performed. It is a curious fact that both bones and tendons will develop a [illegible] repair only if some function is required of them. This correspond[illegible] Wolff's law of bone repair

Muscle and Tendon Transplantation.—These [illegible] essentially different. The reëstablishment of a mo[illegible] stitution of a tendon attached to a healthy muscle [illegible] perform the function of another depends on [illegible] technic in both the operation and the after-care. [illegible] as the other By the physiologic method of [illegible]

by Mayer and Biesalski the tendon to be transplanted is removed carefully from its bed after a long incision to expose its course. The mesotenon is carefully cut, and the tendon is slipped into the sheath of the tendon of the paralyzed muscle This provides the tendon with a physiologic sheath and overcomes in large part the greatest obstacle to the resumption of function, adhesions. The first consideration of physical treatment is to prevent adhesions If the insertion of the tendon is firmly anchored into, and not onto bone gentle passive motion can be started within the first two or three days, and active or assisted active motion in two weeks Massage of the operative scar is begun as soon as the skin wound is healed to prevent scar formation in the operative wound Unless reëducation of voluntary motion is soon begun, the patient may never learn to use the revised muscle-tendon system. The gross movements must be reëducated before the finer ones. Coördination of the entire extremity can be reëstablished by rhythmic exercise of the larger joints first, then the smaller ones.

The transplantation of muscle origins has been recently made practical by the application of the method of transplanting a layer of bone, with the muscle origin to some new bony prominence. An example of this procedure is Dickson s transplantation of the origin of the tensor fasciae femoris from the anterior to the posterior superior spine of the ilium with a bone fragment, for paralysis of the gluteus medius Telson has shifted the anterior portion of the gluteus maximus forward on the iliac crest for the same purpose Bony union in these cases is expedited by minimum voluntary movements calling the transferred muscle into play

Corrective operations for talipes unfortunately, for purposes of after-care of muscles and tendons generally require a plaster cast for over-correction of the deformity or for retaining the fresh bone surfaces in apposition after an arthrodesis Even if a cast is applied, it can generally be bivalved within the first few days and frequently removed for gentle massage baking and the production of a minimum of passive movement in the new implanted tendons. The most satisfactory tendon transplantations in the foot are the peroneus longus to replace the tibialis anticus in equino valgus the tibialis anticus the fifth metatarsal for talipes varus and the peronei with the flexor hallucis longus or tibialis posticus to substitute for the tendo achillis for talipes calcaneus (paralytic) In all three a beginning retraining of muscle action can be accomplished by slight voluntary motion even while the foot is in the cast.

Tendon Repair.—The present tendency in careful plastic surgery is to omit the primary repair of severed tendons in the cases of lacerations of the extremities unless the wound has been a clean incision by a clean object on a clean skin and not contaminated by subsequent soiled dressings in first aid If such a clean wound is seen within a few hours after it is sustained a primary suture may be attempted

otherwise an interval of several months after the orignal skin wound has healed is allowed before the tendons are repaired. The after-care is of tremendous importance. The extremity is put up in a position which completely relaxes the repaired muscle tendon. The length of time allowed before passive motion is instituted depends on the mechanical skill with which the tendons were united. Slight daily passive motion is enough to prevent tiny adhesions within the tendon sheaths Such motion is begun by Koch and Kanavel from the first day in cases where no infection is anticipated. The advent of infection destroys all the benefit of careful and atraumatic surgical repair Bunnell recommends wearing a check rein of adhesive plaster holding the wrist and fingers in flexion for four weeks after repair of flexor tendons of the fingers and later the application of galvanic current to contract the flexor tendon sharply breaking fine adhesions If adhesions constrict the tendons in spite of thorough treatment, a second operation for freeing them, followed by daily passive and active motion is advised

No tendon repair should be done by a surgeon who is not willing personally to supervise the after-care.

Tendon Luxations.—The commonest dislocations of tendons occur at the knee, where the patella may slip outward at the malleoli where the tibialis posticus or the peronei may luxate to a position under the skin at the shoulder by the long head of the biceps leaving the bicipital groove or in the hand where the extensor tendon of a finger may slip off the knuckle In partial luxations especially when due to mechanical trauma splinting followed by exercises to strengthen muscle groups stabilizing the tendon motion may be successful In complete luxations and those accompanying congenital deformities or due to poor muscle and tendon development operative fixation of the tendon in a newly prepared vinculum tendinum of fascia or periosteum followed by the usual physical treatment after the tendon operation is more successful.

Vaginal and Mucous Bursae

It is important to emphasize that there is no essential difference in the types of affections which involve the two types of bursae Churchman says that Albinus in 1734 described sixteen pairs of sacs between tendons and bones and called them "bursae mucosae" to distinguish them from the sheaths about the tendons of the wrist and ankles which Winslow had already identified and described as "bursae vaginae" Piersol has said that bursae are sacs filled with liquid found in various places where friction occurs between different layers or structures The tendons are often surrounded by [illegible] and according to Piersol's definition, the joint cavity [illegible] Our consideration is limited to the vaginal or [illegible]

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lining as compared with many of the superficial bursae is that the latter are easily destroyed by disease or scarifying agents and show more tendency to disappear completely after partial resection inflammation or scarification and injury than the former This termination is less important so far as function is concerned and is often the aim of treatment whereas the mucosae vaginae must be intact if tendon function is to be conserved

The Bursae Vaginae.—Several anatomic and physiologic considerations arise in connection with tendon-sheath pathology and treatment. Bunnell (Fig 20) has shown that the protective covering and

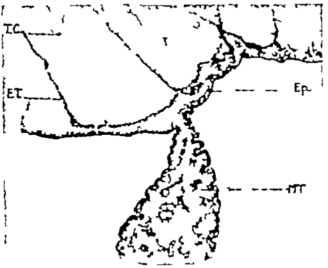

FIG. 2 —Microscopic cross section through the hilus of the extensor longus hallucis tendon (adult) Leitz obj 3 oc. tube 140. T C. tendon cells E. T endotenon Ep. epitenon M. T mesotenon

The mesotenon expands at its insertion into the tendon, forming a delicate tightly adherent connective tissue enveloping layer—the epitenon. From the epitenon connective-tissue septa extend int the tendon separating it into larger and smaller bundles. These septa I ha e termed the endotenon (old terminology peritenonium internum) as opposed to the exotenon, the connecti tissue coating the surface of the tendon. Within the sheath the exotenon is represented by the epitenon and the mesotenon above the sheath and at the two portals of the sheath by the paratenon. (From Lewis, Practice f Surgery Hagerstown, Md., W F Prior Co., Inc., 1931)

blood supply differ in the longer tendons depending on whether the tendons exert a straight pull or must pass at an angle or around a corner to reach their attachment. In the former case a tendon glides in the paratenon a specialized fat between the tendon and the firm fascial compartments in the vicinity Here the blood supply is ample being supplied by branches from the muscle and helicine or tortuous vessels passing through the paratenon and long enough to follow the tendon movement. The loose fatty tissue is attached to the tendon and glides with it. Fatty tissue is notably slow in developing fibrosis

ing tendons and the bursae mucosae The former have the distinction, important in therapeutics, of having a true synovial lining the stratum synoviale, while the latter are provided, according to Piersol, with a "more or less cellular lining,' the degree of perfection of this synovial lining in the bursae mucosae being less complete in the subcutaneous than in some of the deeper bursae. According to Hamar, and also Braun, the synovial membrane of bursae is neither epithelium nor endothelium but real connective tissue and therefore, of mesodermal origin and Jones has, consequently suggested the name 'mesothelium.' The importance of the development of specifically differentiated and secreting lining membrane in the tendon sheath

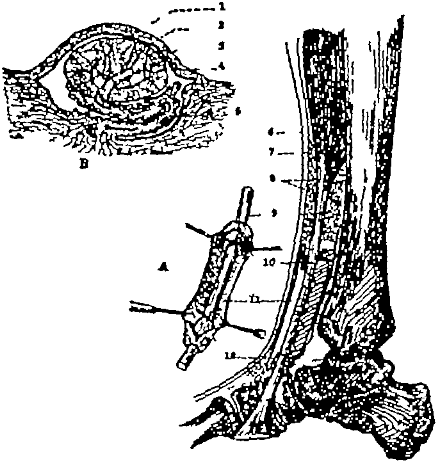

FIG. 21—Anatomy and gliding mechanism of a tendon (tibialis anticus diagrammatic) Showing the proximal part of the tendon enclosed in paratenon fat and just below it where the tendon turns a corner when in dorsiflexion showing the tendon passing through its sheath and obtaining its blood supply through its mesotenon.

(A) The sheath is looked into from the front, showing a plica duplicata at the upper end and plica simplex at the lower

(B) Cross section of tendon in sheath showing the relaxed blood vessel-bearing mesotenon. 1 tendon, -endotenon, 3-epitenon, 4-sheath, 5 mesotenon with vessels, 6-skin, 7 fascia, 8-paratenon, 9-tendon, 10-plica duplicata, -sheath 12-plica simplex. (From Lewis, Practice of Surgery Hagerstown Md W F Prior Co., Inc., 1931)

from using a scoop in filling bags and repeated supination in turning heavy ledger sheets The reader is referred to Bunnell s excellent article on synovitis in 'Lewis Surgery The pressure of puttees or heavy shoes on the peroneal and Achilles tendon results in exquisitely painful synovitis about the ankle

As the tendon sheath becomes congested and roughened fibrin is deposited on the synovial surface and often a pathognomonic tendon crepitus can be felt or even heard on motion Effusion with a tender sausage-shaped swelling along the course of the tendon may eventuate

The symptoms may subside with a few days rest and immobilization but return when the offending motion is resumed These constitute one of the most troublesome types of minor injury with which the industrial surgeon is confronted as he is never able to make a definite prognosis the most insignificant case sometimes being disabled for weeks or months In the management of both the acute and chronic stages absolute immobilization of the joints whose motion causes pain is indicated For this affection in the thumb and extensors of the wrist and fingers a cock up splint serves admirably If the flexors are affected a dorsal splint, with the fingers and wrist completely flexed is better In all cases the fingers must be completely immobilized Massage in our experience is disastrous and heat is best applied as diathermy for one to two hours daily The danger of fibrous adhesion development in the traumatic case is an important one Some cases can return to work after all pain on motion has disappeared wearing a leather wristlet or a liquid-plaster wrist and hand splint (Fig 20)

Pyogenic Tenosynovitis.—The advent of tendon-sheath infection after trivial infected wounds of the fingers or hands requires immediate and wide surgical incision to drain thoroughly the sheath to the limits of involvement Before the wound has healed passive motion to prevent fibrous-tendon and tendon-sheath adhesions is imperative This may seem radical but is urgently advised Dry heat and passive motion with light stroking massage are indicated in the same case as the motions of nearby joints must be conserved from the very beginning of treatment.

Gonorrheal Tenosynovitis.—In the course of an acute or chronic gonorrheal infection a tenosynovitis may occur Often this is described by the patient as following some minor contusion or strain The industrial surgeon must be on the look-out for such an etiology in every supposedly traumatic case Complement fixation and smears from the genitalia aid in deciding The prognosis in these cases is much worse as regards loss of function from adhesions and ankylosis than almost any other type of synovitis. The course is prolonged Vaccine therapy occasionally yields a startlingly rapid improvement. Active and passive motion and manipulation are contraindicated at all stages of treat

and adhesions after injury or infection, hence the danger of constricting fibrosis in this portion or type of the tendon-muscle system is at a minimum. Operations for tendon repair or revision are best performed here. When gliding around a curve the tendon moves in a smooth lubricated tendon sheath lined with synovial membrane. This sheath is a closed sac, indented at the two ends to allow for motion of the tendon within it The lubricating fluid changes with inflammation and too much or too little fluid is the source of symptomatology Pain on motion results from roughening of the synovial lining. Constriction of this sheath which is, even under normal conditions, snug, interferes with the gliding and constricts the blood supply to the tendon This blood supply to the tendon in its sheath generally reaches it through a loose mesentery, the mesotenon, capable of stretching in either direction to accommodate the limit of tendon motion (Fig 21) If this is inflamed the vessels which it carries are constricted, causing tendon ischemia or congestion with subsequent damage. The mesotenon may shorten from chronic inflammation, causing fibrosis and binding the tendon restricting its motion mechanically This delicate arrangement of a tendon in a snug sheath, with a lubricating fluid content and complicated blood supply, makes this a point of election for adhesive tenosynovitis and the constrictive affection first described by de Quervain as "stenosing tenovaginitis" This is a poor site for tendon operations In some locations near tendon insertions, and in some individuals at all points in the sheath-enclosed tendon, it is entirely devoid of mesotenon. The tibialis posticus and flexors of the fingers are examples of this lack of adequate blood supply What small blood supply these tendons receive must arrive from either end by tiny vessels in the tendons themselves The slightest degree of inflammation or edema of the tendon obstructs this imperfect supply entirely The tendon so supplied is in the worst possible situation for operation or repair or for resistance to infection.

Tenosynovitis

The etiology of tendon-sheath inflammation may be traumatic infectious either pyogenic or specific (such specific types as gonorrheal tuberculous or syphilitic) or may occur as a part of systemic disturbances like gout or "rheumatism" The objective in the treatment of all is the preservation of the function of the sheath if possible.

Traumatic Tenosynovitis.—This may occur as a result of a single contusion or of repeated performance of an unfamiliar motion The commonest type of the latter seen by the author occurs in the wrist around the tendons of the long abductor and the short extensors of the thumb The exercise of the wrist in rowing playing golf or tennis, or using a hammer may affect the flexors of the fingers and wrist. The commonest occupational synovitis in the author's experience results

Stenosing Fibrous Tenosynovitis of de Quervain.—In 1895 de Quervain, of Basle Switzerland described five cases of this malady but no mention of it appears in American literature until Schneider of Milwaukee reported fifteen cases in 1928 In all these cases the sheaths of the abductor pollicis longus and the extensor pollicis brevis were affected where these tendons pass under the superficial dorsal carpal ligament although from clinical observation we know that a similar process probably develops about the ankle, particularly around the peroneal tendons after os calcis fracture and about the extensors at the wrist. Some of the cases of de Quervain and Schneider resulted from monotonous use of the thumb occasionally following a single trauma to the dorsum of the wrist while some appeared to have a "rheumatic' background Roentgenograms revealed a calcareous deposit on the radius at the site of the fibrocartilage disk probably in the diseased tendon sheath where it is closely adherent to the bone. De Quervain found a fibrosis in the middle layers of the tendon sheaths. Nussbaum in operating on these described five layers in the sheaths with the middle layers composed of firm connective tissue arranged at right angles to each other that is, one longitudinal and the other transverse. These two layers presented marked fibrosis constricting the sheath which was too narrow for the tendon to pass

These patients complain of severe pain on extension and abduction of the thumb being often entirely unable to accomplish these motions. Even gripping and ulnar motion or extension of the wrist may produce pain A thickening may be palpated on the dorsum of the lower end of the radius but there is no redness or crepitation on motion. Despite rest of the extremity and the application of electric heat, the pain becomes increasingly severe Schneider cured seven cases in ten by the application of a plaster splint including the thumb and forearm but several were relieved only by surgical intervention In some as de Quervain suggested he split the involved tendon sheaths including the dorsal carpal ligament and applied a cast Later heat light massage and active motion were given and in the operative cases, all recovered completely

Decompression operations based on this principle are advised in all cases of chronic synovitis in which the subjective symptoms are not relieved in a reasonable time—four to six weeks—by complete immobilization and baking Many months of loss from remunerative employment can be saved the patient by timely surgical intervention in resistant tenosynovitis

Bursitis

For purposes of treatment *bursae mucosae* can be considered in two classes (1) Superficial and subcutaneous bursae which vary considerably in size number and position and are not necessary to the function of moving structures All remedial treatment can be

ment until months after all subjective symptoms have disappeared. Adhesions cannot be prevented in this affection Ankylosis and fibrosis must be expected. The probable loss of function should be explained to the patient early in the course of treatment

Tuberculous Tenosynovitis.—This commonly affects the sheaths of the extensor or flexor tendons at the wrist or, less commonly those about the foot and ankle Early in the course, it is mistaken for a mild tenosynovitis resulting from a trivial injury, but the progression of swelling due to either serous effusion or perisynovial hyperplasia, without much tenderness redness or pain marks the case as the result of some specific granuloma. There may or may not be a demonstrable focus of tuberculous infection elsewhere If a nearby joint is involved the diagnosis is quite simple. The distinction from a syphilitic affection cannot easily be made except by the serologic tests on the blood or cerebrospinal fluid If syphilis is diagnosed the local treatment of the synovitis is greatly aided by general specific treatment. Tuberculous synovitis can be approached in two ways by the conservative treatment, such as used for joint tuberculosis comprising complete fixation of the part aided by both local and general heliotherapy and by hyperalimentation The general care of the tuberculous patient is as important as rest of the focus of infection If after several months the local disease is progressing—that is swelling increases and sinuses appear as the process is extending along the muscle-tendon system—or there is evidence of necrosis of tendon, complete excision of the tendon sheath and pathologic tissue in the vicinity including the necrotic tendon must be performed. Kanavel seems inclined toward this radical treatment early in the course of the disease as leaving a better condition in which to begin reconstructive and reëducative treatment of the remaining intact structures of the part Bunnell suggests early incision into the tendon sheath and the introduction of 5 per cent iodoform in glycerin followed by prolonged immobilization on a splint. However the general rule can be made that if a tuberculous focus in the tendon sheath is not improving in appearance after a few weeks of splinting one sort or other of surgery is indicated

Rheumatic and Gouty Inflammation of the Tendon Sheath.—This is diagnosed by the occurrence of foci elsewhere In the rheumatic affection the tender swelling may appear suddenly A history of various joint muscular or bursal affections elsewhere makes a diagnosis. The acute stages demand splinting and gentle baking After the local focus of infection or allergic reaction has subsided heating followed by passive motion and retraining of atrophied muscles aids in preventing deformity and loss of function The general physical treatment of rheumatism is of as much importance as local measures.

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Decompression operations based on this principle are advised in all cases of chronic synovitis in which the subjective symptoms are not relieved in a reasonable time—four to six weeks—by complete immobilization and baking Many months of loss from remunerative employment can be saved the patient by timely surgical intervention in resistant tenosynovitis

Bursitis

For purposes of treatment *bursae mucosae* can be considered in two classes (1) Superficial and subcutaneous bursae which vary considerably in size number and position and are not necessary to the function of moving structures. All remedial treatment can be

directed toward the obliteration destruction and removal of these structures since they are not necessary to the function of the part. Furthermore constant or repeated pressure easily results in the formation of a new adventitious bursa wherever such a structure is needed Inflamed bursae of this type can be aspirated and the lining scarified or injected with escharotics After aspiration, large doses of diathermy followed by compression bandaging may result in their obliteration If purulent infection develops, wide incision and packing or complete surgical removal results in a cure

(2) The deeper bursae are of far greater importance in function. They may be classified as (a) subfascial aiding the motion of fascial planes upon each other (b) submuscular which are between two muscles between a muscle and some skeletal part or between a muscle and a tendon (c) subtendinous bursae which are between tendon and bone, between tendon and ligament or between two tendons (d) periarticular bursae like the bursae subscapularis and bursae subcruralis which often connect with a contiguous joint. These deeper bursae are important as being the location of much obscure pathology and mistaken diagnosis The surgical approach is often difficult or exposes important structures so that surgical removal is not always feasible without a destructive operation The tendency to communicate with nearby joints accounts for the danger of the extension of an infection from bursa to joint

Being quite like the tendon sheaths and joint cavities in development and anatomy the bursae mucosae present the same pathologic reactions to trauma, infection and irritation as do the former structures In chronic bursitis resulting from trivial trauma or repeated unusual motion the question of a rheumatic element in the inflammation always enters the mind of the examiner

Because of the complicated arrangement and contiguity of important structures all types of bursal pathology except purulent infection should be given the benefit of thorough and prolonged physical treatment before operative intervention is contemplated. For an intelligent approach to the treatment by physical means the physician must visualize the probable pathology of the bursa and surrounding structures at different stages of inflammation. Deering has admirably classified these stages somewhat as follows

1 Acute reactions with effusion or fibrin deposition beginning.
2 Fibrous adhesions forming and contracting with associated fascial fibrosis and sometimes periarticular fibrosis in a contiguous joint
3 Muscular atrophy
4 Calcium and fat deposition in the bursa or obliterative fibrosis.

Sometimes the inflammation begins insidiously with no acuity stiffness of nearby joints and pain on motion being the first complaint. The early local treatment consists of heat, particularly diathermy, and absolute rest of the part in a position relaxing pressure upon the

affected bursa. Gentle massage up to the pain threshold maintains muscle nutrition and relaxes spasm. This if unrelieved would result in muscle atrophy and fibrosis Elevation is indicated in cases of hyperacuity or pathology suggesting pyogenic infection Repeated aspiration is indicated in the first stage as long as the bursa is markedly distended with fluid In the second stage fibrous adhesions in the bursa and nearby tendon sheaths or between muscles must be prevented even at the expense of some pain to the patient by means of gentle manipulations and active stretching exercises to maintain joint, tendon and muscle movement Heat is continued

Often the case is seen first during the third stage when the acuity has subsided but much associated pathology of muscle atrophy and fibrositis is already established. Besides the physical treatment already mentioned forcible manipulation under gas is necessary in graded operations however at each treatment only a few degrees of one movement being attempted and followed by massage and baking For instance in the neglected third stage subdeltoid bursitis only a few degrees of abduction of the stiffened and atrophied shoulder muscles are attempted the first time Later complete abduction is accomplished and still later external rotation and, lastly internal rotation Faradic stimulation of functionless muscles with a Smart Bristow coil initiates muscle retraining Assisted exercises follow the institution of voluntary muscle action

In the last stage when calcium salt or amorphous fat can be seen filling the bursa diathermy has an almost specific action in hastening its resorption

Special Forms of Bursitis

The chronic cases presenting no positive roentgenologic findings are often mistaken for traumatic periostitis neuritis articular synovitis a primary affection of nearby tendons or their sheaths or myositis A definite diagnosis is imperative to enable one to make a decision between operative and physical treatment.

Bursae About the Shoulder—All types of inflammation in the structures about the shoulder joint are characterized by pain on motion of the joint limitation of motion and a tendency to hold the arm adducted against the side It is difficult to make an accurate differential diagnosis of the pathology and the etiologic factors involved in this symptom picture. The subdeltoid or subacromial bursa is the most frequent of the structures outside the joint cavity proper to present lesions of traumatic or inflammatory etiology A fall on the outstretched arm brings the greater tuberosity smartly against the acromion process Continual exertion with the arm hyperextended irritates structures covering these bony processes in a less violent manner If the patient has a tendency to synovial irritation from some chronic toxemic or allergic reaction affecting joint and synovial

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tion of the supraspinatus tendon In lesions of this tendon internal rotation and abduction are more painful than external rotation and abduction which latter are more painful in the subdeltoid affection An x ray taken with the arm rotated outward, the tube focused from a position close to the base of the neck and directed downward and posteriorly is likely to show the supraspinatus pathology while an ordinary anteroposterior flat plate visualizes the subdeltoid bursa clearly The distinction in subdeltoid and supraspinatus pathology from the standpoint of treatment is an important one since chronic inflammation in the former yields much more readily and uniformly to diathermy and the abduction splint than the latter which gives a much more hopeful prognosis of function return after early operation for removal of the pathology in the tendon. Harbin finds the area of degeneration and calcium deposition often entirely limited to the tendon at operation without any associated changes in the subdeltoid bursa The tissues within and beneath the deltoid muscle share with those about the elbow joint in a characteristic tendency toward cal cium deposition after injury or irritation Schujenioff found that calcium may be deposited in the deltoid muscle fibers within 36 hours after suture of a laceration of this muscle. Calcium deposition proceeds *pari passu* with a tendency to fibrosis making any shoulder injury particularly likely to result in early stiffness and limitation of motion

Acromial bursitis is quite superficial and the inflamed bursa can be palpated near the surface at the top of the acromion.

Tenosynovitis of the long head of the biceps presents a tenderness far anterior under the deltoid and along the bicipital groove External rotation and extension of the shoulder are painful as is bicipital action Local crepitus may be present

Bursitis of the coraco-acromial subscapular and infraspinatus bursae is rare and the tenderness is localized and not adjacent to the subdeltoid tender points. The first may be located under the coracoid process in front, or farther anterior beneath the combined tendon of the coracobrachialis muscle and the short head of the biceps. The subscapular bursa lies between its muscle and the joint capsule with which it typically communicates and inflammation rarely involves this without, or is diagnosed separately from disease of the joint proper

Periostitis of the humerus at the deltoid insertion may be traumatic from forcible deltoid action or associated with myofascitis here Abduction is painful but no other signs of subdeltoid bursitis are present and x ray may show a local roughening or exostosis of the periosteum. These yield slowly to diathermy but shoulder joint motions can easily be preserved.

Brachial neuritis or radiculitis with or without roentgenologic evi dence of cervical arthritis is more tender at the nerve exits from the cervical spine and tends to produce pain radiating along the upper border of the trapezius and definitely down nerve trunks of the arm.

surfaces, less friction is necessary to produce serous or plastic reac tions of bursal surfaces

Codman investigated the pathology of subdeltoid bursa reactions 23 years ago and described this bursa as follows "Its base is formed by the tuberosity of the humerus and the tendons of its rotators, which are inserted into the tuberosity Its roof is formed by the periosteum beneath the clavicle, the coraco-acromial ligament and the acromion, and by the upper part of the fibers of the deltoid muscle. Its limits beneath the deltoid muscle vary considerably, but the outline is likely to be trilobar like a clover leaf and to extend below the edge of the point. On the whole it is circular in outline, concavo-convex in shape, and about the size of the palm of the hand" The sensory nerves arising from the shoulder joint and from this large subdeltoid bursa, which may be spoken of as an accessory shoulder joint go to the same cord level which supplies motor impulses to the muscles in close proximity to the shoulder joint, and sensory irritation is reflected to these muscles as protective spasm fixing the shoulder in adduction and slight internal rotation This position is identical with that of decerebrate rigidity and allows the powerful adductors and internal rotators to stretch the weaker external rotator and abductor groups. The establishment of function of the weaker group about any joint is more difficult than rehabilitation of their stronger antagonists, particularly when the stronger group, as here, are the "gravity muscles' with "plastic tone" On physical examination the greatest tenderness is found either over the middle of the deltoid or over its insertion or distributed in both of these points. Pain on abduction may begin with the first few degrees of motion and be localized on the outer aspect of the arm at the deltoid insertion, or suddenly appear at about right-angle abduction localized just below the acromion. No pain or tenderness should be expected in the uncomplicated subdeltoid lesion over the anterior border of the deltoid or about the bicipital groove of the humerus In examining shoulder motion, it is an important item of technic for the examiner to seize the scapula firmly and prevent its rotating motion to replace the shoulder joint motion in the stiffened or painful shoulder Codman's test of having the patient flex the spine forward and let the arms hang down then arise bringing the arms up to the horizontal with the body is impor tant. When this maneuver is performed a sharp pain is generally experienced in the shoulder when the erect position is resumed and the humeral head is brought up against the acromion.

In 1906 Dawbarn described a sign rather characteristic of prolif erative changes or calcium deposition in the supraspinatus tendon in studying subdeltoid bursitis but Stevens in 1909 first recognized a distinction between the former condition and subdeltoid bursitis proper The sign mentioned consists of a point of tenderness just above the tuberosity of the humerus which disappears under the acromion on extreme abduction of the arm. This is rather constant in calcifica

tion of the supraspinatus tendon In lesions of this tendon internal rotation and abduction are more painful than external rotation and abduction which latter are more painful in the subdeltoid affection An x ray taken with the arm rotated outward the tube focused from a position close to the base of the neck and directed downward and posteriorly is likely to show the supraspinatus pathology while an ordinary anteroposterior flat plate visualizes the subdeltoid bursa clearly The distinction in subdeltoid and supraspinatus pathology from the standpoint of treatment is an important one since chronic inflammation in the former yields much more readily and uniformly to diathermy and the abduction splint than the latter which gives a much more hopeful prognosis of function return after early operation for removal of the pathology in the tendon Harbin finds the area of degeneration and calcium deposition often entirely limited to the tendon at operation without any associated changes in the subdeltoid bursa. The tissues within and beneath the deltoid muscle share with those about the elbow joint in a characteristic tendency toward cal cium deposition after injury or irritation. Schujenioff found that calcium may be deposited in the deltoid muscle fibers within 36 hours after suture of a laceration of this muscle Calcium deposition proceeds *pari passu* with a tendency to fibrosis making any shoulder injury particularly likely to result in early stiffness and limitation of motion

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The median or circumflex trunk may be tender to palpation in the lower third of the arm

The principles of treatment correspond to the general rules for the management of bursitis anywhere Immobilization on an abduction splint, with complete external rotation, often cannot be accomplished until gradual stretching of the contracted adductors and internal rotators has restored motion to the shoulder Confinement to bed in the supine position with the arm in a sling tied to the head of the bed aids in gradual abduction. Most disabilities of the shoulder joint are best immobilized in this position If calcium deposits are not resorbed from the bursa after a few weeks' administration open operation is indicated for the removal of the contents and as much of the thickened bursal wall and underlying periosteum as can be exposed in the field Physical treatment must continue thereafter

Of the deeper bursae about the elbow the ones under the tendinous insertion of the triceps or within the fibers of this insertion are difficult to approach surgically without some damage to an important muscle tendon Not enough fluid collects in these bursae to be successfully aspirated. A surrounding fibrosis is the most troublesome feature. Radiohumeral bursitis, epiphysitis' or tennis elbow, characterized by severe pain over the outer side of the elbow and a point of tenderness over the external epicondyle is generally considered as due to inflammation of a small bursa lying between the conjoined tendon and the radiohumeral joint. These have been operated on successfully by Osgood but can in our experience, be treated successfully by complete immobilization of the elbow in semiflexion and with the forearm in the midposition between pronation and supination. Diathermy is applied daily up to the "toleration' dose. This treatment should relieve all symptoms in three to six weeks Active motion of the arm can then be resumed but violent exercise or the performance of the peculiar type of movement originally responsible for the irritation should not be repeated. Recurrences are common and if a chronic painful stage develops, operative interference should be undertaken.

Several deep bursae about the hip require physical treatment. Bursitis about the great trochanter is easily mistaken for osteomyelitis tuberculosis of the hip or epiphysitis Careful diagnosis is essential Splinting rest in bed and diathermy are successful if treatment is continued for a long enough period and no suppurative process is present. The iliopectineal and iliopsoas bursae vary in size and position Inflammatory processes here can be mistaken for psoas abscess femoral hernia or coxitis Aspiration may aid in diagnosis and treatment Physical therapy should be given a prolonged trial before operative intervention Pathology in the ischial bursa is easily approached surgically and should be dissected out.

Subcutaneous bursae about the bony points of the feet and ankle vary considerably in distribution Adventitious bursae readily develop from constant pressure of shoes upon bony swelling and deformities.

Typical of this is the bursa commonly appearing and frequently the seat of pain and swelling over a bunion Surgical dissection may leave tender scars when care is not exercised in choosing a skin flap which will not leave a suture line passing over a bony prominence The deeper bursae, when inflamed are generally not palpable but produce exquisitely tender areas in characteristic locations Sharp bony spurs may grow from the periosteum beneath or protruding into, contiguous ligaments or fascial planes These osteophytes must be thoroughly excised with the underlying periosteum before physical treatment of the inflamed bursa can be undertaken There are four distinct sets about the os calcis capable of producing disabling symptoms

1 At the attachment of the adductor hallucis brevis the flexor digitorum brevis muscles and the plantar fascia just beneath the sustentaculum tali is the anterior calcaneal bursa. It lies beneath the short flexors of the foot and anterior to the posterior tubercle of the astragalus in a region of difficult surgical approach

2 More superficial than this on the inferior surface of the tuberosity of the os calcis and covering this bony prominence, is the posterior calcaneal bursa.

3 Anterior to the Achilles tendon, on the neck of the os calcis lies the retrocalcaneal bursa.

4. Anterior and internal to this bursa and in close relation to the tendons of the posterior tibial and flexor longus digitorum muscles are other bursae of irregular size and position

In chronic stages of inflammation roentgenologic evidence of thickening or calcium or fatty contents may be seen Baking and the maintenance of the part in absolute immobilization will alleviate the symptoms of the bursitis

Pitfalls in the Physical Treatment of the Muscle Tendon System

1 The most important pitfall applying to muscle as to all physical treatment is the danger of treatment of the local pathology without a careful physical examination and history to rule out the etiologic factor of a general disease or distantly located cause for the local pathology

2 Tumors and swelling of tendons and muscles should be approached from a standpoint of physical treatment only after a positive diagnosis is made. Benign tumors of the former are surgical. Little can be expected from physical means before the mechanical interference of the swelling with function is removed No muscle tumor can be trusted not to become malignant Physical treatment may aid in its dissemination or metastasis

3 Increased swelling tenderness superficial congestion pulsation or telangiectasis developing while a muscle is under treatment carries

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the suspicion of malignancy X ray should check this possibility from time to time

4 Myositis ossificans represents the culmination of a constitutional tendency The connective tissue of injured or inflamed muscles tendons and fascia progressively changes to bone The brachialis anticus and other muscles about the elbow, which are commonly affected, develop increasing stiffness during a course of physical treatment. Rest should be immediately substituted for massage and motion which increases the calcium deposition Roentgenograms indicate the stage when bone ceases to be deposited and the resulting bone can be surgically removed

5 Trichinosis should be suspected when myositis becomes more acute during treatment and a biopsy on the affected muscle reveals the encapsulated larvae. Physical treatment should be replaced by anthelmintic management until the acuity passes in the course of weeks

6 Syphilis and tuberculosis of muscle tendon and tendon sheath must constantly be borne in mind watched for and appropriately managed by general antisyphilitic treatment or the adoption of a régime for the cure of tuberculosis

7 The *bête noire* of tendon treatment is fibrosis Early slight motion is infinitely more successful than delayed and more robust treatment.

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CHAPTER SEVEN

PERIPHERAL NERVE LESIONS

Lewis J Pollock, M D

Injury or disease of a peripheral nerve produces among other things a loss of motion which if complete is called paralysis and if incom plete, paresis Not all of the loss of motion seen in peripheral nerve lesions is the result of the defective conduction of such a nerve Some of it may be the result of local shock pain swelling of tissues fractures dislocations adhesions ankylosis contractures of opposing uninjured muscles spasm sclerosed fibrous tissue, as in ischemic paralysis tendon and muscle section or loss and hysteria.

Examination

Many of the nerves when injured produce a paralysis of certain muscles which leads to a characteristic deformity Of such mention may be made of the wrist drop of radial nerve palsy often associated with "tumor of the wrist" due to distention of the ligaments producing a protrusion of the proximal metacarpal bone the position of a foot drop in peroneal nerve palsy the characteristic clawing in ulnar nerve palsy the ape hand in ulnar and median nerve palsy the winged scapula in long thoracic nerve palsy etc

Limitation of movement of joints frequently results and the range of motility may be determined by a goniometer and measured in degrees of a circle or by tracings obtained from moulds with a flexible lead tape (Fig 1) first obtaining a tracing of the position in one direction (flexion) and then in the opposite direction (extension)

When examining for a range of passive movement attention must be given to the position of the extremity and its parts for example flexion of the fingers is more limited with the hand flexed at the wrist than extended Similarly in combined ulnar or median nerve lesions extension of the fingers will be more limited when the hand is extended at the wrist. Dorsal flexion of the foot will be limited with the legs extended in peroneal nerve lesions

Movements of Segments About Joints.—It is impossible to examine each muscle separately for evidence of paralysis and we are com pelled to infer its functional capacity by the active movements of segments about joints In such an examination the part of the extrem-

sively moved active motion may continue the movement and if a position of the extremity is passively imposed, the paretic muscle may hold the extremity in this position.

The amount of weakness may be determined by comparing the strength of movement against gravity or interposed resistance either with a dynamometer or with the unparalyzed side or the examiner s resistance. A simple dynamometric method may be employed by interposing a spring scales between the segment to be examined and the examiner s hand Each movement about the joint may be so examined and recorded Pronation and circumduction may be investigated by fastening a small flat piece of wood in the patient s hand and inserting the hook of the scale in a hole drilled through the wood (Fig 2)

Many factors other than paralysis produce loss of function and require treatment Changes in the joints are a very common complication of peripheral nerve lesions They may result from fractures into

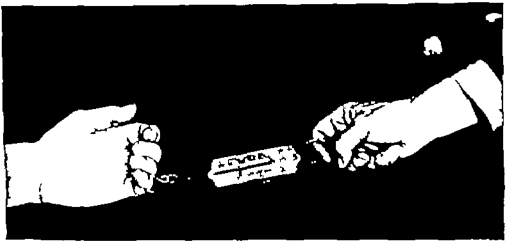


Fig. 2—Spring scale dynamometer

the joint, dislocations suppurations of the joint and nearby parts immobilization ischemic contractures etc.

Occasionally an early arthritic change consisting of painful swelling is seen which may persist for weeks and be followed by partial ankylosis. At other times gradual retraction of muscle tendons and hardening of the capsule of a joint occur Such changes are more often encountered in partial and painful nerve lesions such as are seen in injury of the median and tibial nerves Interphalangeal joint changes are particularly disabling and care must be exercised to prevent them if possible

Shortening and contractures of opposing unparalyzed muscles occasionally occur at times because of neglect to splint the extremity at times because of prolonged overcorrection and at times despite good treatment.

ity proximal to the joint being examined must be immobilized For example in testing for extension at the wrist, the forearm should be immobilized Care must be exercised in properly evaluating that loss of function which results from the deformity's producing defective action of opposing muscles, such as the defective flexion of the fingers resulting from the wrist drop of radial nerve palsy

The extremity must be placed in such a position that the force of gravity will be nullified An enfeebled muscle may be able to move part of an extremity when supported but not when opposed by gravity, as in circumflex nerve injury the deltoid muscle may be strong enough

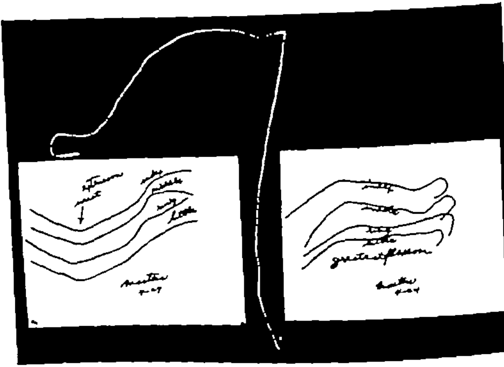


FIG 1—Lead tape and tracings.

to produce abduction of the arm if the arm is held supported on a powdered board but too feeble to produce movement with the arm dependent.

At times the movement produced by gravity might be misinterpreted as active motion for example, extension of the forearm after flexion has been produced with the patient standing erect is of course, only the result of gravity controlled by the unparalyzed biceps

At times no motion of the extremity may be produced but a contraction may be felt in the paretic muscle by palpation or relaxation may be felt upon contraction of the opposing muscles as in paralysis of the deltoid muscle strongly resisted adduction of the arm is accompanied by relaxation of the deltoid. At times if a part of an extremity is pas-

Special attention should be directed to the misinterpretation of certain movements which are possible or become so after certain nerves have been injured. Unless one is familiar with these supplementary or trick movements a completely paralyzed muscle may be thought to have recovered function Such movements result from the anastomotic supply of muscles from adjacent nerves from the action of muscles other than those which are primary movers For example, flexion of the wrist may be produced by contraction of the extensor ossis metacarpi pollicis, by movements resulting from mechanical factors when tendons act over several joints Extension at the wrist may be produced by complete flexion of the fingers in radial nerve palsy (Fig 3), by the elastic recoil of movements in the opposite direction as the extension of the distal phalanx of the thumb following flexion and by gravity

Response to Electrical Stimulation.—The response of muscles to electrical stimulation often gives indication of the state of recovery or function. Normal muscles and nerves react to electrical stimulation in a characteristic manner The make or break shock of a galvanic current produces a rapid lightning like twitch of the stimulated muscle, and faradization produces a tetanus The muscles react to the stimulation of the negative and positive poles in a constant manner and a formula of polar contraction may be expressed as follows (K. C C) Kathodal closing contraction is greater than (A C C) Anodal closing contraction is greater than (A. O C) Anodal opening contraction is greater than (K. O C) (K. C C > A. C C > A. O C > K. O C)

Ten to fourteen days following injury to a peripheral nerve certain changes occur in the reaction to electrical stimulation which, grouped together constitute the reaction of degeneration (D R.) These changes may be described as quantitative qualitative modal and polar The excitability of the nerve to faradic and galvanic stimulation is lost. The muscle loses its irritability to the faradic current (qualitative) In the early stages for about two weeks the muscle is hyper excitable to the galvanic current, but later becomes less and less excitable (quantitative) The character of the response changes from a rapid twitch to a slow vermicular contraction (modal) The polar formula is reversed the A. C C being greater than the K. C C The most valuable and most constant of these signs is the slow contraction of the muscle.

Because of the diffusion into unparalyzed muscles when a unipolar method of stimulation is used the bipolar method wherein both poles are placed upon the muscle being examined is preferable The extremity to be examined must be relaxed and the segments about joints must be so supported that the muscles are not required to act against the power of gravity Supplementary movements may be produced by electrical stimulation and one must be alert to recognize these

Atrophy is a common accompaniment of paralysis of a muscle resulting from peripheral nerve lesions Study of the amount of tissue loss following such lesions shows that the cases carefully treated by physical therapy have far less loss of volume of the tissues of an extremity than do the untreated cases

FIG. 3—Extension of wrist by supplementary motility

Sclerosing fibrous tissue as in ischemic paralysis or associated with vascular lesions produces long-lasting loss of function which is very resistant to treatment The loss of function does not follow the motor distribution of any peripheral nerves and the responses to electrical stimulation are not characteristic of reaction of degeneration but there is a diminution of response to both faradic and galvanic current.

Where a primary or secondary suture is indicated immediately physiotherapeutic treatment must assist the operative procedure. When it is felt advisable to defer the operative procedure, physical therapy must be initiated promptly to the end that when the nerve regenerates it will activate a mechanism capable of adequate movement.

The above indications are met by treatment with splinting to prevent overstretching of paralyzed or weak muscles massage to improve the nutrition of the parts to prevent adhesions of scars and fibrosis and to conserve the bulk of the muscle passive movements to prevent deformity from shortening interphalangeal fibrosis ankylosis of joints active exercise to conserve the unparalyzed muscles to stimulate circulation to educate synergistic muscles to assume the function of paralyzed muscles electrotherapy to conserve the vitality prevent complete atonia and increase the contractility of paralyzed muscles and hydrotherapy and thermotherapy to assist in nutritional conservation and to facilitate other methods of treatment.

In cases treated some time after injury splinting and the other procedures are indicated to correct deformities as well as to restore function Here passive movements must include stretching of shortened muscles and tendons and mechanical devices constructed to assist in this function. Corrective exercises and occupational therapy play a large part in the correction of such deformities

Splints to Prevent Deformity —The purpose of the splint is to put the paralyzed muscle at rest and prevent overstretching of the muscle and to resist spasm of the opposing muscle. Each splint must be devised for a particular patient because the mechanism of the joints over which the paralyzed muscles act differs in each individual. The splint should be light simple easily applied and removed inexpensive and as inconspicuous as possible The material from which splints are constructed differs in the hands of various workers In general the splints used by the British and French during the World War were far more complicated than those used in America. Aluminum is a satisfactory metal to work with. It is light and when necessary small adjustments may easily be made in the shape and other characters of the splint, as indicated.

Following a primary or secondary suture, particularly the latter where it is often necessary to place the extremity in an abnormal position to permit of approximation of the severed ends of the nerves a plaster of paris cast or splint must be applied for a period of two weeks Following this a removable splint should be applied Starched crinoline may be used in preference to plaster of paris as it is much lighter and therefore much more comfortable.

It is important to note the danger of applying a splint and regarding this as the only indicated treatment. Many patients have been incapacitated by the fibrosis which has resulted from the prolonged and uninterrupted use of splints So much is this the case that in many

Electrical examination likewise is often valuable to differentiate loss of motion due to severed tendons from paralysis In the former, galvanic stimulation followed by a good contraction in the muscle, fails to produce a movement of that segment to which the tendon is attached

An electric stimulus must reach a certain intensity before it will result in the contraction of a muscle This minimal current, however must be prolonged for a certain length of time to produce a response. At "infinite duration" there is a minimum strength below which no contractions occur (rheobasic voltage) As the duration is decreased the strength must be increased until a point is reached where, no matter how strong the current, no contractions follow Twice the minimal current which will produce a contraction in unlimited time has been designated empirically as the chronaxia of the tissue. The chronaxia of a human muscle with an intact nerve supply has been found to be 0.00016, whereas that of one whose muscle has degenerated is about 0.01 It was hoped that measurements of the chronaxia would furnish accurate information of diagnostic and prognostic value in peripheral nerve injuries Although they have served to give precise measurement of the functional value of nerves and muscles in physiology, because of the inaccessibility of accurate instruments and the unreliability of certain others few data are available which permit of critical judgment of their clinical value Measurements by the condenser system of Lewis Jones have failed to impress the American investigators with their reliability More accurate methods, such as the Lucas pendulum, Lapicque s chronaximeter Strohl s ergometer and Sachs and Malone s chronomyometer have appeared to give accurate information in their several investigators' hands It is possible that they may lead to profitable clinical investigations in the future.

Indications for Treatment

Physical therapy methods hold the first place in the treatment of peripheral nerve lesions Following a peripheral nerve lesion the objects to be attained differ somewhat under various conditions. If a primary suture is possible or if the patient is brought for treatment soon after injury where an operation is not indicated we aim to prevent deformities and to restore function. When some time has elapsed after injury and a secondary suture or neurolysis is necessary the aim is to correct deformities and restore function. The same is true in similar cases not requiring operation

Operative procedures of suture and neurolysis will not serve to restore function They only make it possible for the nerves to regenerate. It is conceivable that perfect regeneration might occur in the nerve and an extremity be functionless because of interphalangeal fibrosis, retraction of capsular ligaments, marked atrophy and fibrosis of muscles shortening of muscles spasms of muscles and ankylosed joints.

instances of long delayed restoration of function it was possible to envisage the character of the splint which had been used by the position of the extremity For example the ill advised use of a cock up splint often caused fibrosis and shortening of the extensors and ankylosis was present at the wrist. It is equally important that one should not apply a splint devised for one nerve lesion upon an extremity in which a totally different nerve is paralyzed for example, a cock-up splint should not be applied in the case of a median nerve lesion.

The application of a splint should not blind us to the necessity of other treatment and it is imperative that electrotherapy, massage passive movement etc. be continued throughout the time of immobilization Although some clinicians believe that no adhesions will form if a splint is applied so that only relaxation is obtained and not over relaxation this has not been my experience. Not only must joints not concerned with the movements of the paralyzed muscles be moved daily but when supported the involved joints must be moved Certainly no harm can occur from gentle passive movements sufficient to produce movement but not overstretching It is well not to produce overcorrection A position midway between the extent of movement in the opposite direction is by far preferable in most muscles Only slight extension at the wrist is sufficient to produce rest of the paralyzed and atonic extensor muscles of the wrist. Each individual nerve injury has some general indication which should guide us in the consideration of the splint. Such splints can be better illustrated than described and the general indications will be discussed and the types of splints illustrated.

Circumflex Nerve.—Injury to this nerve produces a paralysis of the deltoid The patient is unable to abduct the arm and the weight of the unsupported arm often results in a subluxation of the head of the humerus and at least a marked stretching of the capsular ligament. The indications are to keep the arm abducted and partly externally rotated. The abduction should not be beyond 60 The forearm should be flexed and held in moderate supination Such a splint may likewise be used in upper brachial plexus injuries (Figs 4 5)

Ulnar Nerve.—Paralysis of the ulnar nerve is easily recognized by the appearance of the hand with clawing of the little and ring fingers inability to grasp objects between the thumb and forefinger because of paralysis of the adductor pollicis and inability to make a cone of the hand by approximating the tips of the fingers and thumb because of paralysis of the interossei Lateral movement of the fingers is possible only through supplementary movement and the patient is unable to innervate the muscles of the hypothenar eminence (Fig. 6)

Although many devices have been constructed for the treatment of ulnar nerve lesions in general the majority of cases recover more completely without the use of these cumbersome appliances They

FIG. 4—Paralysis of circumflex nerve.

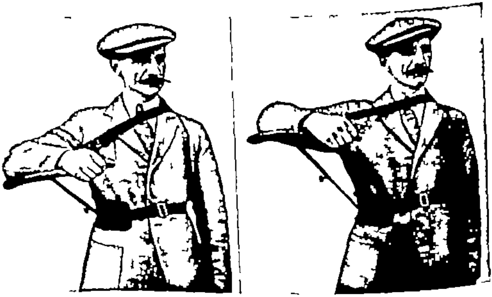


FIG. 5—Splint f circumflex nerve palsy (From The Diagnosis and Treatment of Peripheral Nerve Injuries, Medical Research Council.)

little and ring fingers may be applied as illustrated Extension of the distal phalanges of the little and ring fingers may be defective because of overextension of the proximal phalanges and a device which prevents these phalanges from overextending is useful in recovering lesions A narrow strip of metal running diagonally across the palm from the base of the third to the base of the little finger then bent to continue in the opposite direction over the backs of the proximal phalanges of the little ring and middle fingers, is often serviceable (Fig 7)

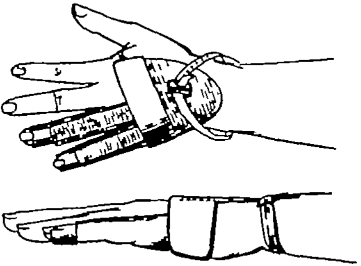


Fig. 7—Splint for ulnar nerve palsy (Chiray and Dagnan Bouveret.)

Median Nerve.—Paralysis due to a lesion of the median nerve produces an inability to appose the thumb to the little finger to abduct the thumb at *right angles* to the palm to flex the index finger as in making a fist or clasping the hands and to flex the distal phalanx of the thumb (Fig 8)

For the most part what is true of the ulnar is likewise true of the median nerve There is but little clawing of the index or middle finger and flexor contracture of the index finger does not occur The only troublesome complication is a shortening of the adductor of the thumb and at times it is necessary to hold the thumb in abduction at a right angle to the palm. A light hollow aluminum ball between the index finger and thumb with the fingers semiflexed assists. A hollow cylinder will serve the same purpose Occasionally an apparatus which by means of a spring supplants the abduction of the thumb may be serviceable although in general springs are unsatisfactory

Combined Ulnar and Median Nerve Lesions —Combined ulnar and median nerve lesions when complete produce inability to perform

interfere with the motility of unparalyzed muscles which suffice to move all of the segments about the joints of the hand. The only disabling complication which follows ulnar nerve lesions is clawing of the little or little and ring fingers. Passive movement commonly suffices to prevent this. When it appears that clawing will result from overaction of the extensor communis digitorum, a simple posterior splint for the

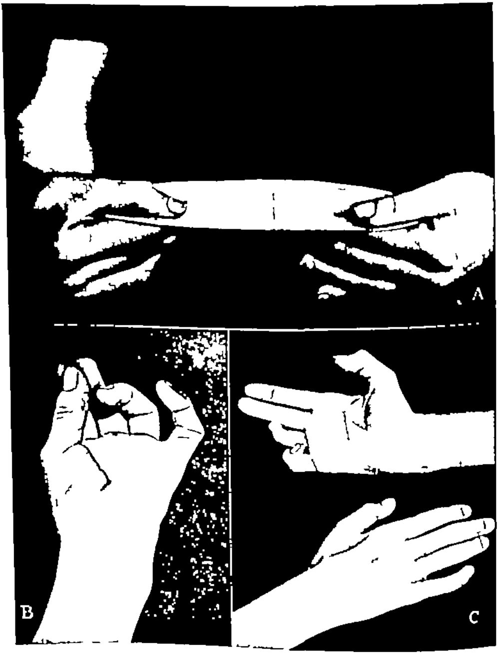


FIG. 6—Ulnar nerve palsy. *A*, ulnar paper sign. *B*, inability to make a cone with fingers. *C*, clawing.

any flexor movements of the fingers or hand Under such a condition a simple anterior splint supporting the hand in a slightly flexed position suffices Clawing occurs in all the fingers and counter pressure should be exerted against the backs of the proximal phalanges The thumb should be fixed in a position of abduction at right angles to the plane of the palm (Fig 9)

Partial lesions of these two nerves are particularly liable to be complicated by adhesions shortening and deformity and require much more attention than complete lesions

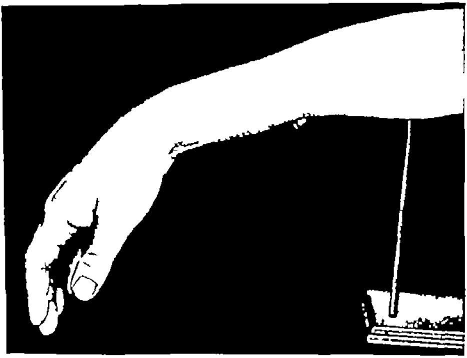
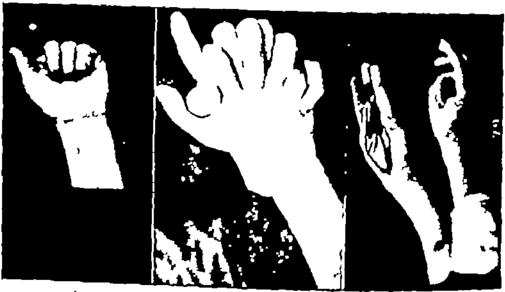


Fig. 10—Radial nerve palsy

Radial Nerve.—The indications in cases of paralysis due to a lesion of the radial nerve are to extend the wrist and the proximal phalanges of the fingers and thumb in a plane with the palm (Fig 10) The following splint as described by Buerki and used in the United States Army is very satisfactory

Spring steel wire covered with rubber tubing at all points of pressure and properly bent has been found to make a light and comfortable splint. It will meet the requirements and overcome some of the objections of other types This splint is made from a piece of No 11 spring steel wire 35 inches long

It is best to start bending the splint on the ulnar side of the arm. Nine inches from the end the wire is bent upward to form an angle of 140 From this point the wire extends forward to the junction of



A B C

Fig. 8—Median nerve lesion A defect in making fist. B defect in clasping hands. C defect in opposing thumb to little finger

Fig. 9—Combined ulnar and median nerve lesion.

patient from the sharp ends The palmar arch support is made from No 20 spring steel wire covered with rubber tubing and is attached to the splint by adhesive plaster The ends are one inch long and are bent in opposite directions from each other to increase the stability of the palmar attachment. The wire first extends downward away from the splint for an inch on each side and then by a slow curve extends upward to support the palmar arch. A piece of adhesive plaster is now placed on the splint just above the wrist and folded on itself so that all of the sticking surface is covered Finally the canvas band is slipped over the ends coming in contact with the flexor surface of the forearm. This splint can be made in fifteen minutes It is applied without bandages and can be readily removed or put on by the patient without assistance (See Fig 11)

Musculocutaneous Nerve Lesions —Stookey has described a simple and efficient apparatus which may be used to aid in the treatment of lesions of this nerve The important muscle which is paralyzed is the biceps Fortunately there is little or no likelihood of overstretching the biceps or of markedly shortening the triceps because of the mechanics of the elbow joint and the fact that other unaffected muscles act upon both the shoulder and elbow joints However at night a mechanical support which keeps the forearm flexed with the hand in full supination should be worn Stookey's apparatus consists of a broad leather cuff attached to the wrist and dorsum of the hand The wristband has a metal plate which is shaped to fit the dorsum of the hand and wrist. Supination is maintained by a strap fastened to the wristband over the volar surface of the radius which passes outward and under the wrist This strap is then fastened to a collar piece by a pin or snap

Brachial Plexus Lesions —Of all the peripheral nerve lesions none require more constant and efficient mechanical treatment than those of the brachial plexus

As has been pointed out previously in general lesions above the clavicle are injuries of the roots and primary cords whereas those below the clavicle or in the axilla include the secondary cords and nerve trunks These latter are frequently accompanied by injuries of the axillary blood vessels There are two general types of injuries the Erb-Duchenne or upper root group which involves the fifth and sixth cervical roots and the lower root group or the Klumpke-Déjerine type, which involves the seventh and eighth cervical and first thoracic roots In the former the resulting paralysis is extensive and involves the muscles of the shoulder girdle and back as well as muscles of the arm and forearm In the Klumpke Déjerine type the paralysis is essentially of the ulnar side of the forearm and all of the muscles of the hand (Fig 12)

the proximal and middle phalanges of the little finger, where it is bent at a right angle in the same plane Three-fourths of an inch from here it again receives a right angle bend but this occurs in a plane at right angles to the previous one This bend causes the wire to run across the palmar surface of the fingers, and thereby extends the proximal phalanges on the metacarpal bones A right angle bend in the same plane at the outer side of the first finger, and another bend three-fourths of an inch farther on in a plane at right angles to it, complete

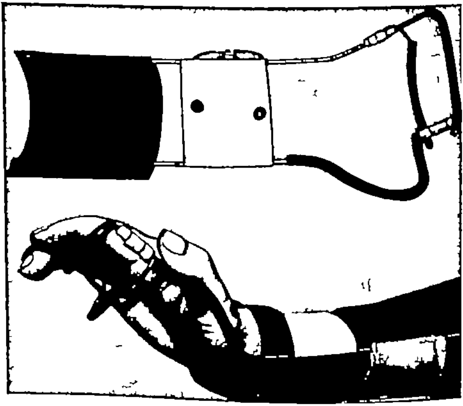


FIG. 1 —Splint for radial nerve palsy (Buerkl.)

that part of the splint which keeps the hand in place The wire then runs backward along the outer side of the first finger until it reaches the point opposite the base of the distal phalanx of the thumb where it is bent outward at right angles to extend the thumb on the first metacarpal bone. When it reaches the outer side of the thumb the wire is curved downward and inward to the wrist following the thumb as nearly as possible in its extended position The wire is now bent so that it runs parallel to and in the same plane as the wire on the ulnar side of the forearm. The two rubber tubes which protect both the fingers and the thumb from the splint are now slipped into place and then the ends of the wire are bent on themselves thus protecting the

nerve high in its course. The branches to the semitendinosus and long head of the biceps are given off at the level of the ischial tuberosities and consequently these muscles are spared The semitendinosus alone is able to perform the functions of the hamstring muscles to a high degree. It is also able to supplement the action of the gastrocnemius

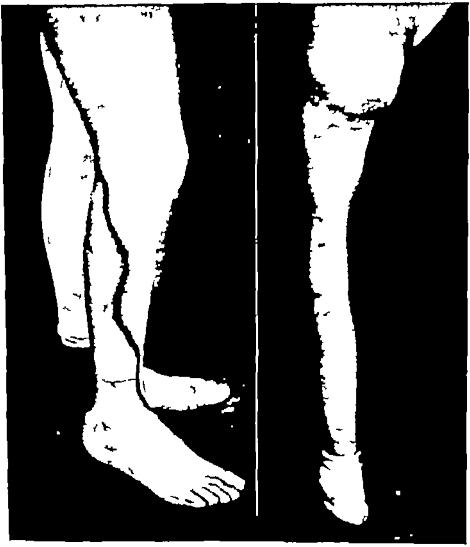


Fig. 13—Sciatic nerve lesion.

in flexing the leg upon the thigh. However all the muscles below the knee are paralyzed and the leg is flaccid while the foot is dropped and in a valgus position It is necessary to stabilize the leg and foot to correct the equinovalgus deformity and to overcome faulty deviation of the body weight (Fig 13)

The most effective and comfortable splint is one based upon the Thomas caliper type It is light comfortable and efficient It should

In those lesions in which the muscles of the back (serratus magnus, rhomboids levator scapulae) are involved, the deformity is extensive. The compensatory movements of the scapula are diminished or absent. The action of the serratus magnus in fixing the scapula so that the deltoid may act is gone and this must be kept in mind in devising mechanical support. The arm lies adducted with inward rotation The humerus may soon subluxate and in old neglected cases may be dislocated completely The coracoid process becomes prominent and the forearm is held in semipronation Because the entire extremity is rotated inward the palm of the hand may face backward. Left alone without mechanical support these lesions are followed by permanent and irreparable deformity

A splint must be designed to relax the deltoid and the supraspinatus muscles and at the same time hold the arm in external rotation The

FIG. 11—Lower brachial plexus lesion.

arm must be held in abduction, preferably at an angle of about 60 rather than in abduction at 90 The arm should be rotated externally and the forearm flexed upon the arm and held in moderate supination. Stookey has described a satisfactory splint for these cases It is made of aluminum and consists of a chest, an adjustable arm and a forearm piece The arm piece is hinged and may be adjusted to various angles of flexion

The deformity present in the Klumpke-Déjerine or lower root, type of paralysis is similar to that seen in combined median and ulnar nerve lesions A slight straight splint on the volar surface of the forearm, with grooves for each of the fingers proves quite satisfactory The straps should be placed so that voluntary extension of the fingers is possible.

Sciatic Nerve Lesions.—Paralysis of all the muscles supplied by the sciatic nerve is uncommon even with a complete section of the

side of the foot This will correct the varus deformity The ankle joint may be supported if necessary by a leather reinforcement sewed to the shoe The flat foot may be corrected by an inside plate which should be made to fit individually by molding plaster casts of the foot deformity The principal aim must be to correct all the deformities and to prevent those which may result from the improper distribution of weight bearing The patient should be cautioned never to walk without proper support of his foot. A rubber band or metal spring may be attached to the shoe and the upright to aid in replacing the lost action of the extensors

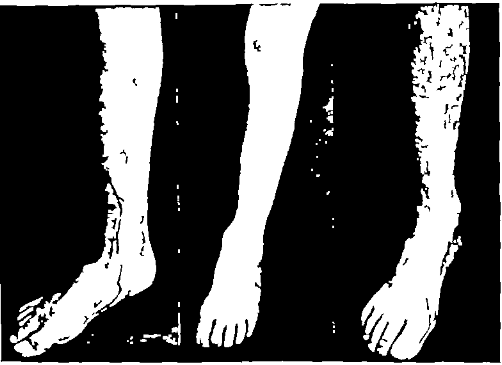


FIG. 15—Peroneal nerve palsy

An adequate splint for the foot drop of *peroneal nerve lesions* was used in the United States Army It had the advantage of simplicity lightness and relative service As described by Buerki it is made of two pieces of wire weighing but two and one-third ounces It is serviceable because it not only holds the foot well extended at all times but it also aids in walking as it gives the foot the normal flexibility which is lacking in all of these cases Pieces of bronzed spring steel wire 25 inches long have loops three-fourths of an inch long bent on each end in opposite directions (Fig. 16 Diag 1) The lower loop is for aid in attaching a wire around the shoes while that at the top protects the clothing from the sharp wire To give the splint flexibility the wire has a one-and three-quarters turn coil three-fourths inch in diameter

be so arranged with a spring lock at the knee joint that while the patient is sitting the knee may be flexed to an angle of 45° A sole plate should extend from the heel to the metatarsophalangeal joint and should be attached to the upright so that the foot is held in dorsiflexion The heel of the shoe should be raised on the inner side and the shoe reenforced there so that the valgus deformity will be corrected and the patient at the same time, will bear his weight upon the outer side of the foot when he walks. This will aid the weakened arches which naturally accompany these lesions Another sample splint is shown in Figure 14

PERONEAL NERVE LESIONS —The deformity in these cases is one of foot drop and a varus deformity due to complete paralysis of the

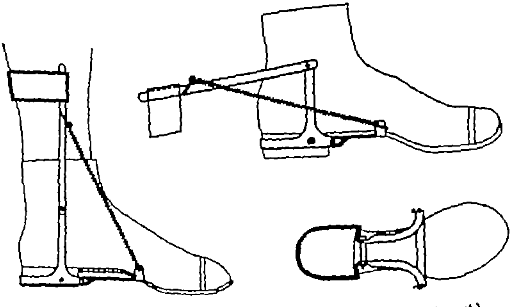


FIG 14—Splint for sciatic nerve lesion. (Souques, Mégevand and v Donnet.)

anterior and lateral muscles of the leg The os calcis is raised considerably because of the unapposed action of the gastrocnemius. Flat foot occurs because of the lack of support to the arches by paralysis of the peroneal group and extensors attached to the inner side of the foot. A very serious disability in walking exists because of the over action necessary to keep the toe from scraping the ground (Fig 15)

It is necessary to splint these patients for more than a toe drop. A light iron strip on the inner side of the leg attached to the shoe with a stop lock will prevent a foot drop It should be so attached that it raises the foot in dorsiflexion. The iron strip is attached above to a leather band about the leg The leg should be elevated on the outer side from the heel to the toe to deviate the body weight to the inner

should have a stop lock which will prevent dorsiflexion to more than a right angle The inner border of the sole and heel should be so raised as to deviate the body weight to the outer side and to correct the val gus position As in the case of the peroneal deformities an inside plate fitted individually should be worn to support the weakened arches

The splints for these last two types of deformities cannot be worn at night but their main action should be replaced by canvas appliances

Fig 17—Femoral nerve lesion.

which will effectively prevent overstretching of the paralyzed muscles Without the use of these nocturnal supports all that has been accom plished during the day may be easily undone

Femoral Nerve Lesions —As has been stated lesions of this nerve are accompanied commonly by injuries to the pelvic vessels and

bent into it six inches from the lower end (Fig 16, Diag. 2) This coil when in place is directly opposite the junction of the sole and heel of the shoe Two wires bent as described above, are held in place, one on each side of the shoe, by four pieces of fine piano wire, one piece under the instep, another around the heel at the junction of the upper and the heel, the third under the sole connecting the lower extremities of the wire and the fourth around the toe between the sole and the upper The last piece binds the splint permanently to the shoe. It is best to apply the wires in the above order (Diag. 3) The splint is completed by a piece of double ply canvas six inches wide and four

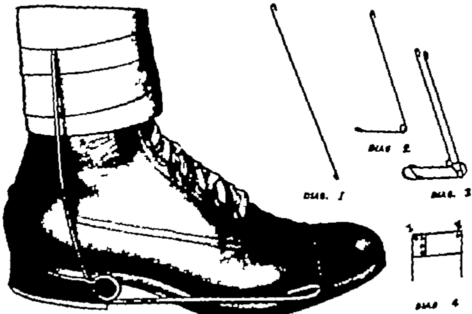


FIG. 16—Splint for peroneal nerve palsy (Boerid.)

inches long and held together by five rivets placed as shown (Diag 4) Rivets I and II keep the splint from slipping through the canvas. The canvas is slipped over the upper end of the splint, around the calf and the whole is held in place with a special legging The splint lasts from two to three months.

TIBIAL NERVE LESIONS.—The deformities present in these cases are practically the opposite of those described as the result of injuries of the peroneal nerve lesions The unopposed action of the peroneal muscles pulls the foot into dorsiflexion and the os calcis is directed downward instead of backward The foot tends to assume the valgus position and the longitudinal arch flattens because of the paralysis of the tibialis posterior and the small muscles of the sole of the foot.

Mechanical support may be given in the form of a light iron strip on the outer side of the leg attached to the sole of the shoe. This

may become so stretched that an eversion of the lower eyelid may occur (Fig 18)

The simplest type of support consists of two adhesive straps The point of pull should be attached to the temporal area and the support

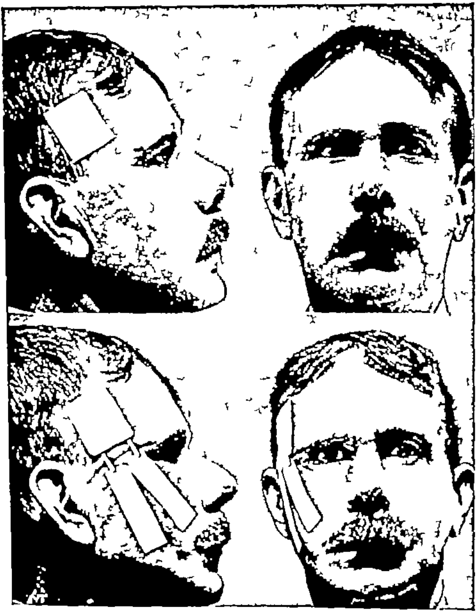


FIG. 9—Splint f facial palsy (N S Yawger)

ing straps should be attached to the skin about the upper and lower lips The ends of the two straps may be attached by a rubber band so that an elastic pull upward is maintained This support must be worn constantly It is simple and is easily detached during massage electro-

viscera. Consequently, one is not called upon frequently to provide mechanical support following such a lesion However the quadriceps femoris sartorius and pectineus muscles are paralyzed and there is an inability to extend the leg upon the thigh A patient with a femoral nerve lesion is unable to stand upon his leg unless the knee is in extreme extension The knee joint soon becomes so unstable that it may suddenly flex and allow the patient to fall When walking, the patient usually bends forward and places his hand on the thigh to keep the knee joint securely extended The tensor fasciae latae may act to hold the joint in fixed extension and then the patient assumes a swinging gait. In old neglected cases a genu recurvatum may develop (Fig. 17)

Mechanical treatment must provide stability to the knee joint and yet prevent hyperextension A Thomas caliper splint with a spring

FIG. 8—F cial palsy

lock which allows of flexion of the knee only while sitting is the most efficient type of splint A broad band in the popliteal space will prevent hyperextension and the occurrence of genu recurvatum.

FACIAL NERVE LESIONS.—The facial muscles must be protected from overstretching and sagging after interruption of their nerve supply just as other muscles. The mechanical support of these muscles contributes tremendously to the recovery of their action after a nerve supply has been reestablished In neglected cases the muscles

serve the functional capacity of paralyzed muscles until sufficient nerve regeneration has taken place to permit of active motion.

The efficacy of this type of treatment has been called into question on a number of occasions Although since the days of Duchenne neurologists have universally agreed that electrotherapy is of service in hastening the return of function of muscles paralyzed as the result of lesions of the lower motor neuron, some physiologists have decried its usefulness (Langley) On the other hand many physiologists have determined upon the basis of experimental studies that there is a sound foundation for the belief that electrotherapy is serviceable in the treat ment of peripheral nerve lesions Not only have most of the workers found decreased atrophy in treated cases but recently Piontkovskiy has shown that a more advanced type of regeneration of the nerve occurs when the denervated extremity is treated by electrotherapy

Mode of Action —It is necessary to understand clearly the mode of action of treatment by electricity It is not concerned with any mysterious force acting directly upon the factors influencing recovery of a nerve or muscle. Stimulation by an electric current of sufficient strength produces a contraction of the muscle. It is this active con traction of the muscle which conserves its bulk and nutrition and keeps the muscle fibers functionally adequate for voluntary movement when regeneration has progressed sufficiently In cases such as facial nerve paralysis contractures are diminished and associated movements so often of disfiguring and annoying consequence likewise are prevented. The only requirement of electrotherapy is that it shall produce a contraction of the paralyzed muscle Obviously this cannot be brought about by stimulation with the faradic current, as the duration of each shock is too short in relation to the changed chronaxia of the nerve and muscle Galvanic current must therefore be used It may be used in its simple form of a continuous current, or in the form of sinusoidal currents of various types of waves

It has been proposed that the continuous current which at the make or break produces a sharp shock-like contraction is of little value as it does not resemble a normal contraction of the muscle, which it is said is imitated by the contraction ensuing as the result of stimulation by the sinusoidal current. Of course the criticism that it acts only locally may be met by the statement that larger electrodes should be used That muscles contract slowly in their normal state has never been shown to be the case by physiologists The twitch contraction due to electrical stimulation is thought to be analogous to the phasic con traction of all skeletal muscles It may I believe be accepted as a fact that the contraction of a muscle resulting from stimulation by galvanic continuous current is as useful as that produced by any other type of galvanic current. The rapidity of the contractions can produce no harm after the second week following injury or surgical procedures and during the first two weeks the muscles should be kept practically

therapy and active exercises which are practiced by the patient (Fig 19)

Corrective Splinting —When, because of fibrosis of muscles and joints, or because of spasms or contractures of muscles, deformities have taken place, the problem of splinting is a very different one. The indications are to lengthen the shortened muscles and tendons and to mobilize the joints The splints are devised therefore with the view of exerting elastic tension upon the segment of a joint involved in alternating directions for certain periods during the day So-called

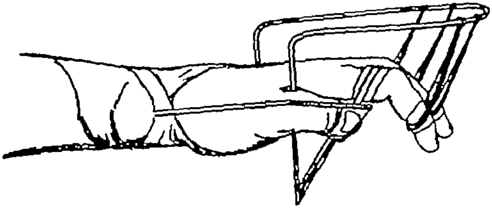


FIG. 20—Apparatus of Dubé. (Chiray and Dagnan Bouveret.)

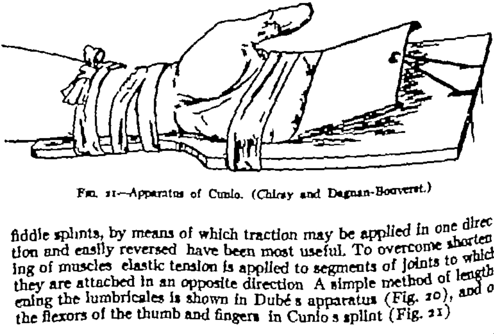


FIG. 21—Apparatus of Cunio. (Chiray and Dagnan-Bouveret.)

fiddle splints, by means of which traction may be applied in one direction and easily reversed have been most useful. To overcome shortening of muscles elastic tension is applied to segments of joints to which they are attached in an opposite direction A simple method of lengthening the lumbricales is shown in Dubé s apparatus (Fig. 20), and of the flexors of the thumb and fingers in Cunio s splint (Fig. 21)

Electrotherapy —The indications for electrotherapy are to prevent atrophy of muscles and fibrosis to increase nutrition and to con

a movement with the extremity in a position of foot drop but if the patient rests the leg on a board at the outer surface dorsal flexion may occur The patient's extremities must be fully supported and the seg ments about joints so supported that movement is not impeded by gravity

Value of Contractions —Contractions of muscles produced by electric stimulation are a valuable adjunct to reëducation and active motion. Although the patient may not be able to produce extension at the wrist voluntarily the hand may be held in this position after electrically produced extension has occurred A voluntary contraction of a muscle may be possible after it has been produced by electrical stimulation and the patient should be required to attempt such a movement during the period of treatment. Of course one should always keep in mind the law of regeneration. When it is remembered that the extent of regeneration of the nerve after section and suture is one millimeter a day it is futile to have the patient attempt active movement before the fourth month in such cases In severe compressions in which recovery is taking place without operation but which are associated with complete degeneration of the distal segment the same conditions hold true Care must be exercised in treating areas of skin in which sensation has been destroyed as burns are readily formed and ulceration once occurring is difficult to heal.

When the nerve and muscle have recovered sufficiently to contract to faradic stimulation both forms are advisable the latter to produce more prolonged or tetanic contractions An apparatus which permits of stimulation by gradual increase and diminution of current such as is possible with one Bristow coil is valuable as it is less painful Here again it is necessary to state that during the period of severe degen eration the faradic current will not produce a contraction of the muscle and no contraction means no treatment.

Sinusoidal current and other forms of wave currents have only the advantage of relative painlessness There is a seeming advantage in the fact that at times a larger electrode is used and rhythmic con tractions are produced in large muscle groups This is a disadvantage and care should be exercised to stimulate only the paretic muscles

Passive Movement.—As Langley has pointed out intermittent passive or active stretching forces lymph and so presumably metabolic products from the muscles This of course should be an advantage. Moreover such active or passive movements have a distinct influence on the formation of connective tissue. It is said that there is a visible increase of connective tissue in microscopic preparations of a muscle three weeks after section of its nerve. Part of the last contractures may be due to the shrinkage of this newly formed tissue which is soft and extensible Active or passive movements of the denervated muscles will stretch the developing fibers so that when they do shrink there

at rest as they are fragile and are easily bruised After this period sudden contractions are just as useful as slow ones The force of the contraction can, of course, be modified by the strength of the current. Galvanic continuous stimulation is often painful therefore, other types of waves are useful as they are relatively painless and can be used to advantage in children and sensitive patients. It is necessary to remember that the contraction of a muscle occurs only upon making and breaking the current. Therefore it is needless to treat the muscle by prolonged stimulation and the current should be applied with very short makes and immediate breaks of the current by using a suitable electrode

The stimulation may be obtained by using bipolar or unipolar methods In the former both poles are applied to the muscle which it is desired to stimulate In the latter an indifferent electrode of a large size is placed elsewhere upon the body, as described under electrodiagnosis During the first few months following injury, while the muscles are hyperirritable and an increase of direct myotatic irritability may be demonstrated by percussion unipolar stimulation will produce contraction in the muscles most affected by the weakest currents because of longitudinal stimulation Care must be exercised therefore, not to produce too great fatigue in these muscles. One must always keep in mind the fact that in many cases deep muscle sense is defective and the patient is unable to tell when the muscles are fatigued After the first few months the muscles most affected become less irritable to stimulation and unipolar stimulation produces a spread of current to unparalyzed muscles which may alone contract to the injury of the patient. At this time bipolar stimulation is of greater value. A clear knowledge of anatomy and function of muscles is necessary to produce the most benefit. Particularly is this true of the small hand muscles. Inasmuch as the nerve itself is not irritable to stimulation the electrodes need not be placed upon the motor points of the muscles as is the case in paralysis of the upper motor neuron However even the muscle may contract more readily at these points.

Although polar inversion is not always the rule in degenerated muscles it is sufficiently so that the positive pole should be used as the active electrode. It is also the least painful.

In the treatment of ulnar and median nerve lesions, the small hand muscles—the interossei lumbricales adductor and opponens of the thumb and the muscles of the hypothenar eminence—require the greatest attention.

In producing contractions of the paralyzed muscles care must be exercised to prevent the force of gravity from acting against the contracting muscles not only to prevent the detection of movement of segments around the joints but to prevent fatigue Upon stimulating the extensors of the wrist no movement may be seen if the wrist is held dependent, whereas if it is supported upon a board at its ulnar border, extension may take place. The extensors of the foot may not produce

tion of the extremity which is maintained by a splint should be held throughout the treatment. There never should be stretching upon the denervated muscles Massage is begun with a period of rhythmic superficial stroking to obtain further relaxation This may be given in either direction whichever is more pleasing to the patient and the pressure must be so gentle that even centrifugal stroking will not interfere with the circulation Following this gentle stroking all of the muscles of the extremity should be massaged with a centripetal motion to increase the venous and lymphatic circulation More pressure should be used than previously but care should be taken not to injure the paralyzed muscles by compressing them against the bones This may be increased gradually until the massage consists of a gentle kneading

If superficial scar tissue is present, friction massage should be used This is obtained by pressing deeply and moving the hand in a circular direction *The outer tissues should be moved over the underlying* structures with a minimum of movement on the surface. If the scar is dry a lubricant may be used at the end of the friction massage but its use in the beginning makes deep friction impossible If adhesions and contractures are present they must be stretched slowly and gradually Stretching must not be carried to the point where it causes pain or tenderness following the treatment and the movement of returning to the original position must be made as slowly and as carefully as the stretching movement Gentle kneading of the contracted muscles and friction over the ankylosed joints may be performed during this procedure.

Reëducation.—The indications are to train the patient to reproduce voluntarily the movement which has just been provoked electrically or by passive movement. This is the most important part of physical therapy particularly because not only motor regeneration must be complete but sensory regeneration as well in order to effect accurate movement. A certain type of deep sensibility that deals with joint sense is among the last to recover and often never recovers completely An ataxia results even if motor regeneration is perfect It is necessary therefore to treat this ataxia by reëducation

The extremity of the patient must be so supported that the force of gravity does not act against the contraction of the muscle At times it is advisable to have the extremity supported by a sling or a freely swinging board suspended by spiral springs and counterweighted so that the least amount of power is necessary to produce movement. Exercises may be performed to great advantage with the extremity immersed in water Finally the extremity may be placed upon a powdered board so tilted that the above indications are met. The patient is directed to perform a movement and at the same moment the operator slowly passively performs the movement As each normal movement is attempted the patient may be directed to perform the

may be less tendency to a contracture The cut ends of a nerve may become rather fixed to the surrounding connective tissue so that movements may cause a greater pull upon the nerve However, Langley has shown that in this presuture period the tension so placed upon a nerve is not sufficient to cause a rupture of the degenerating fibers.

In many operations it is necessary to fix the limb in a flexed position to permit the cut ends of the nerve to be brought into end to-end apposition In such instances passive movements designed to bring the limb into its normal position may be begun about two weeks after the suture has been made Miller and Lewis have shown experimentally that the tensile strength of a suture line is as great at the end of that time as it is weeks later This is an important fact which allows passive and active movements to be instituted before formidable ankyloses and contractures have occurred

Passive exercises may be carried out very well in conjunction with massage. They help to stretch contractures which have already occurred and to prevent those which invariably occur in a denervated muscle. They also increase the range of motion in an already stiffened joint and help to keep a mobile joint active so that when the time comes it is ready to perform its part in an effector mechanism. Finally such movements help to reëducate the muscles in performing normal movements These exercises should be carried out slowly and gently and never with quick, jerky movements Each separate passive exercise should be individualized and the patient should be required to make the attempt to perform the movement simultaneously or to attempt to hold the part in the position imposed upon it.

In many instances active exercises may be employed to great advantage. For example a median or ulnar nerve lesion at the wrist does not affect the innervation of the long flexor muscles of the fingers and the wrist. Unfortunately it is common to find the phalangeal and carpal joints ankylosed or the muscles atrophied simply from disuse. As Kanavel has pointed out, in practically every case of joint or muscle injury passive motion of the injured part with the help of the sound member combined with voluntary exercises will accomplish a great deal towards the restoration of function if the patient has sufficient intelligence and energy

Massage.—Before massage is begun the part should be exposed to heat for twenty to thirty minutes to obtain as much relaxation as possible. Radiant heat, the infra red light, hot packs or a whirlpool bath of warm water are all useful but should be used with extreme care, particularly because of the ease with which it is possible to burn the skin of a denervated area. The whirlpool bath is preferable because the motion of the water acts as a gentle massage which is pleasing to the patient and gives relief from pain.

Before beginning massage the extremity must be placed in a comfortable position with all the muscles completely relaxed The posi-

CHAPTER EIGHT

PHYSICAL THERAPY IN INFANTILE PARALYSIS

ARTHUR T LEGG M D

INTRODUCTION

Poliomyelitis is a specific infectious disease the causative agent of which is thought to be a filtrable virus Although adults may be stricken with poliomyelitis the disease is primarily one of young children appearing rarely under one year but reaching the peak incidence at about the five-year-age level A marked seasonal incidence is apparent in the consistent recurrence of the disease in the late summer and early fall The disease is most common in temperate climates

In order to follow the course and treatment of anterior poliomyelitis carefully the disease is best considered in four stages

The *first* or *acute stage* includes the constitutional symptoms and the preparalytic and paralytic phases Its treatment should be wholly medical

The *second stage* begins as soon as the temperature becomes normal At this stage sensitiveness is still present and the muscles show paralysis or weakness Early orthopedic treatment for the prevention of deformity should start at this time but no active treatment, such as massage and muscle training until the sensitiveness has disappeared It is during this second stage that most of the spontaneous recovery takes place

The *third* or *convalescent stage* starts when the sensitiveness is over and includes that period when the muscles make the greatest gain in power Active muscle training should be carried on faithfully

The *fourth* or *chronic stage* is the stage after the muscles have finished their rapid gain A certain proportion will have recovered to such an extent that no treatment is necessary other than occasional supervision. The remainder will still need orthopedic care and the majority will still obtain benefit from muscle training and massage This benefit will be shown both in actual although slow gain in muscle strength and in an improved use of the body as a whole in getting around and taking part in normal activities Furthermore badly affected muscles lose tone and function and slight contractures develop into fixed deformities if regular treatment is neglected, even in the chronic stage

movement on the normal side as well If electricity is used to produce a movement, the technic is the same

Although actual movements of muscles paralyzed as the result of a complete section of the nerve do not occur before the fourth month, these exercises may be begun after the third month. Whether supplementary movement, which at times develops during treatment, always retards recovery of paralyzed muscles is a moot question, and if the movement is adequate to function as in paralysis of the deltoid, it makes little difference to the patient. Care must always be exercised to prevent fatigue in the paralyzed muscle

Occupational Therapy —Gymnastics of various kinds, Frenkel's movements etc are valuable Particularly valuable in consideration of the long time required to effect recovery is occupational therapy The type of occupation should be devised to fulfill two requirements first that which will hasten recovery and, second that which, if recovery does not take place, will be of benefit to the patient in the use of the extremity The handles of tools are so constructed as to afford support and exercise to the weakened muscles. Hammers screwdrivers chisels, saws planes, all lend themselves well to exercising the upper extremities and foot pedals of various kinds can be used for the lower ones. The small hand muscles are assisted in recovery by typing basket weaving rug making and fretwork. By the combined use of all the methods outlined a functional recovery may be brought about which justifies the surgical treatment, patience and time expended.

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While the treatment of the acute stage is entirely medical, some knowledge of it is desirable in order to understand the later stages.

First, or Acute, Stage *

The disease usually develops in the patient first as a general systemic process, of short duration in which the child is only mildly ill with slight fever and some variable indefinite symptoms referable to the upper respiratory tract or the gastro-intestinal tract. The patient recovers from this mild indisposition, which is frequently entirely over

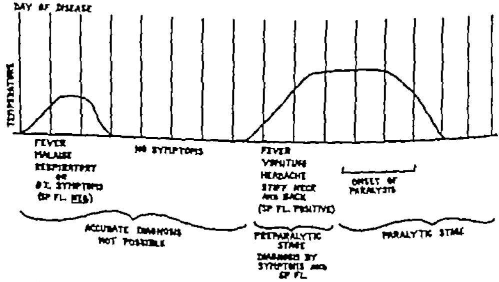

Fig. 1.—Chart showing symptoms and signs in the febrile stage of poliomyelitis

looked appears well for a period up to four or five days and then is again taken ill this time with systemic symptoms plus evidences of central nervous system involvement. Fever headache rigidity of the neck and back and a degree of prostration out of accord with the elevation of temperature usually characterize this stage The face is flushed and the expression anxious The child is usually mentally clear and alert if disturbed but lapses into a drowsy state if left alone.

Whereas spinal puncture done during the first stage of the disease yields normal fluid, spinal puncture during the second stage (or stage of nervous system involvement) yields fluid which confirms the extension of the process to the central nervous system. The spinal fluid is under increased pressure at the first lumbar puncture (although subsequent examination may show a normal or even reduced pressure) The fluid is colorless clear or ground glass rarely turbid and there is present a readily demonstrable increase in the globulin Sugar is present in normal amounts Cells are present in numbers ranging from

* I am greatly indebted to Dr Charles F McKhann for the description of the acute stage.

fifty to several hundred usually lymphocytic or monocytic in type Occasionally and especially very early in the meningitic stage the fluid may be quite turbid and the cell count may run as high as 1500 to 2000 per cu. mm. In these cases the cells may be largely poly nuclears. The high cell counts tend to fall rather rapidly accompanied by a change in the types of cells to those of the mononuclear series

These evidences of acute infection with meningeal involvement last but a few days Yet in these few days of febrile disease the damage is done to the central nervous system and the full basis of paralysis is established

The first appearance of paralysis is usually 36 to 48 hours after the onset of the meningeal stage with the maximum extent of paralysis reached usually within 48 to 72 hours after the first demonstrable weakness With the fall of the temperature to the normal level the danger of further damage to the central nervous system or further extension of paralysis becomes remote

Death from poliomyelitis in the acute stage of the disease is due usually to failure of the respiratory mechanism brought about presum ably in one of three ways

(1) In dorsal involvements directly, by paralysis of the primary respiratory muscles the intercostal muscles and the diaphragm.

(2) In bulbar types indirectly in patients with paralysis of the pharynx, by the collection of mucus or vomitus about the glottis causing either by actual obstruction or by initiating spasms of the glottis constantly interrupted shallow and irregular respiratory efforts

(3) In bulbar types in addition to pharyngeal paralysis directly by disturbance of the nerve centers in the medulla which control respiration.

The last few years have brought definite advances in the treatment of these dangerous forms of the disease advances which fall in large measure into the field of physical therapy For the treatment of the first type of respiratory failure involvement of the intercostal muscles or the diaphragm the Drinker respirator has proved quite effective In the treatment of bulbar forms of the disease without intercostal or diaphragmatic involvement where both the second and third mechanisms of interference with respiration may be operative the results obtained from the use of the Drinker respirator have not been very encouraging

However in view of the observation that patients with bulbar in volvements if they survive show a most remarkable return of function in the paralyzed muscles of the pharynx every effort should be made to maintain life in these patients suffering from high cord or brain stem involvement Much can be accomplished of benefit to patients who have pharyngeal paralysis not complicated by central interference with respiration Inasmuch as patients suffering from pharyngeal

paralysis may succumb to interference with respiration due to collection of mucus or vomitus in the pharynx, or may develop a bronchopneumonia due to the aspiration of this material, the indication is to keep the pharynx dry and free from secretions This can be facilitated by having the patient lie on his side or on his face and by elevating the foot of the bed Aspiration of the pharynx for the removal of secretions may be necessary Patients with bulbar involvement show, in the febrile stage a tendency to vomit so that frequently it seems necessary to rely on parenteral fluids avoiding anything by mouth in these patients until the temperature becomes normal After the temperature drops, the nutrition of the patient may be maintained by gavage feedings In the majority of patients the swallowing function returns in a few days though occasionally postural drainage, aspiration of the pharynx, and gavage feeding may be required for several weeks. Even in these prolonged cases return of function of muscles supplied from the bulbar regions of the spinal cord has been surprisingly good.

Patients who have shown in addition to pharyngeal paralysis, the spasmodic irregular breathing suggesting central interference with respiration have been treated in a variety of ways other than in the Drinker respirator usually without demonstrable benefit. The procedures which have been tried include repeated spinal fluid drainage and the use of hypertonic salt or glucose solution intravenously

Extent of Paralysis and Return of Function

Frequently the extent of the paralysis in patients during the acute febrile stage of poliomyelitis is not immediately and fully appreciated. The pathologic lesion however has reached its maximum, and failure to determine the exact extent of the paralysis is due more to the difficulties inherent in the careful muscle examination of a severely ill patient than to the absence at this time of paralysis which is discovered only subsequently Also before or with the development of paralysis there appears in the majority of cases the muscle tenderness which is recognized as a characteristic of the disease and which interferes materially with an accurate muscle examination.

With the passing of the acute febrile stage there passes the peak of the pathologic process and thereafter any change is usually in the direction of improvement. As noted before bulbar types of involvement are especially prone to show this rapid recovery

A brief statement of the pathologic process aids materially in our understanding of the clinical course and the outlook for return of function in the involved members When the virus invades the central nervous system it incites a marked edema of the cord with considerable perivascular infiltration the development of minute hemorrhages, and almost immediate injury of the anterior horn cells Some of the nerve cells of the anterior horn appear to be destroyed specifically by the virus and removed by infiltrating phagocytes Other cells apparently

are not reached by the specific agent but are seriously impaired in their function by interference with the blood supply probably in turn a result of the extensive edema.

With the subsidence of the acute process the edema diminishes the hemorrhages resorb and the motor nerve cells which have remained viable gradually resume their normal functions. But the cells which are no longer viable continue to degenerate, while groups of phagocytic cells collect to remove this débris When in a given level of the cord a few cells only are destroyed the outlook as regards considerable return of function should be good In very severe involvements all of the motor cells at certain levels may be destroyed and in a few weeks a cavity in the cord may develop where once was a portion of the anterior horn Obviously in cases where this type of extensive degeneration has been found at necropsy had the patient survived little could have been hoped for in the way of recovery of paralyzed members

Unfortunately exact determinations of the extent of involvement can be made only by pathologic examination Clinically the number of patients who show some return of function in a paralyzed part is so large as to justify an optimistic attitude as regards some return of function in *all* cases and the acceleration of this return by proper physiotherapeutic procedures In the paralyzed part in which the passage of time has demonstrated the complete destruction of the nerve supply and the failure of the natural regenerative process the obligation to resort to orthopedic reparative procedures is obvious.

Second Stage

EARLY ORTHOPEDIC TREATMENT

This stage begins as soon as the acute febrile stage is over when the cases are definitely paralyzed or weakened About 80 per cent of the patients will show sensitiveness at this time although others apparently never have any sensitiveness

The objects of treatment at this stage are the prevention of early deformities and the relief of the sensitiveness The sensitiveness can be most easily combated by hot packs given two or three times a day for about fifteen minutes If both arms and legs are sensitive the entire body should be wrapped in wet blankets or towels which have been placed in hot water and wrung out A rubber sheet outside will keep the heat in and protect the bed If only the legs are tender the wrappings may extend from the waist down The heat should not be intense enough to be debilitating or to require the use of ice applications to the head Dry heat from electric pads hot water bottles or radiant light bakers may be applied to the sensitive areas but moist heat has seemed to the writer to be more effective in lessening the sensitiveness due to infantile paralysis.

This stage may last from a few weeks to two or three months. No massage should be given during it Complete immobilization in splints, or in a plaster bed will aid in the relief of the sensitiveness. Unless the case is seen within a few days of onset, the knees and thighs may be already flexed on the body and resist extension It may be necessary to immobilize in this position at the start if the flexion and pain are severe, and gradually bring the legs down as the pain subsides.

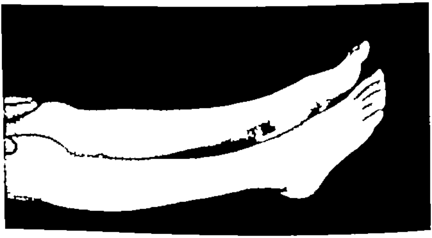

FIG. 2—Equinus—assumed in recumbent position with weak dorsiflexors.

FIG. 3—Copper wire splint for prevention of deformity in recumbent cases.

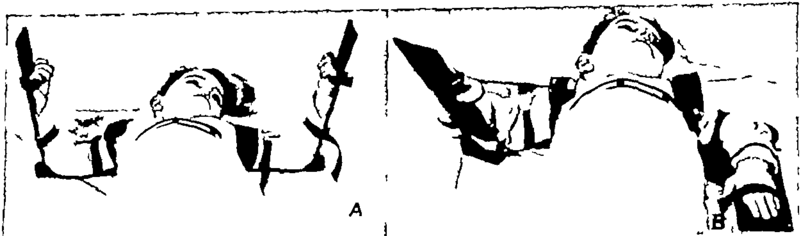

FIG. 4.—A adjustable recumbent abduction splint applied B recumbent bduction splint applied C adjustable recumbent abduction splint applied sitting in bed; D adjustable recumbent abduction splint (unfinished) to allow arms to be put in any position.

In the nursing care of the patient particular attention should be paid to the condition of the skin to prevent bed sores or chafing from the splints A daily sponge bath may be given, followed by a light alcohol rub but the sensitive joints should be moved as little as possible and no brisk rubbing should be given with the alcohol. Any deep massage or too much passive motion, may increase the sensitiveness and prolong this stage

If the limbs are completely immobilized for any length of time in the corrected position the sensitive muscles will shorten in this position, and joint motion will be lost Light passive motion of the knees and hips should be given twice daily flexing each to the point of pain once or twice. Otherwise when active treatment is started it will be found that the patient can not be sat up on a chair because of the tightness of the posterior gluteal muscles at the hip, and the knees can not be bent on account of the tight knee extensors which can not be easily stretched out without permanent damage to the muscles The joints of the arm should be treated in the same way

The general practitioner can prevent deformities and hold the legs and trunk in their normal position by means of sandbags or a box to hold the feet at right angles with the body kept in a straight position by pillows A patient with sensitive shoulders should not be allowed to keep the arms close to the chest and the elbows flexed. A small pillow in the axilla will help to prevent adduction contractures if a splint is not available and a bandage around the wrist may be pinned to the bed to keep the elbow in partial extension

It is far better to utilize pillows even though they must be adjusted frequently to maintain the desired position than it is to put on a solid plaster cast and leave the patient in it for any length of time This interferes with the return of muscle power and produces stiff joints.

Rest is the essential thing during this period and the patients should be moved as little as possible except for necessary nursing care a Bradford frame should be used if it is necessary to carry them. No increase in muscle activity should be allowed before a muscle examination is made.

Third or Convalescent Stage

When the sensitive stage is over active physical therapy can be started.

At this time an examination shows either a definite flaccid paralysis of the muscles affected or if a mild case some degree of weakness. The reflexes may or may not be present according to the extent of the damage in the spinal cord but they are never increased in this stage Some muscles may be contracted from overbalance or from habitual position but they are never spastic The patient's coördination in controlling the muscle power which remains is never affected. If he has the muscular strength to perform the desired motion he will execute it and there will be no ataxic or uncoördinated movements.

The mentality is never impaired and as a general rule the patient s attitude is hopeful and coöperative, although some of the older ones may have more or less depression as they come to realize the extent of their affliction

The circulation of both legs is decreased during the period while the patient is being kept in recumbency and atrophy will follow if the circulation is not kept up Besides this effect of inactivity on the cir culation of both normal and affected muscles there is in many cases some vasomotor disturbance which shuts down the blood supply to a great degree As a result of this we may find later a marked atrophy of the muscles and considerable shortening in a leg where there is very little loss of power while another case with marked muscular involvement may have no shortening at all. However the majority of cases with severe leg paralysis eventually show both atrophy and shortening

While some cases may show some loss of sensation during the acute stage and a few have incontinence or retention of urine these symptoms are never permanent and if present, are a sign of some condition other than infantile paralysis

The classic signs of some other forms of paralysis such as shiny skin deformed nails lack of sensation or anesthesia to heat, pain touch etc are never present in infantile paralysis

This period when the sensitiveness has recently disappeared is the period of most rapid spontaneous recovery Many cases show a remarkable spontaneous recovery in power during the first few weeks after the onset even changing from complete paralysis to normal strength without any treatment whatever This is explained by the fact that the early paralysis was due to pressure on the nerve centers by the edema in the spinal cord without however any destruction of these motor centers With the disappearance of the edema the nerve cells resumed their normal function and the muscles ceased to be paralyzed This spontaneous recovery is often attributed by parents and irregular practitioners to all sorts of batteries lights and applica tions which have no value in themselves.

Before any intelligent physical therapy treatment or reëducation of the affected muscles can be started a complete muscle examination must be made to show the extent of paralysis and the comparative strength of the different muscle groups A muscle examination can be made only by someone who has a thorough knowledge of func tional anatomy and knows the relative normal strength of the different muscles examined Any person without this knowledge of functional anatomy is not competent to make a complete muscle examination nor to carry out intelligent treatment.

It is inexcusable for a physician to turn a case over to a masseuse or a physical education instructor without special training and ex perience in this special branch of physical therapy It is not sufficient for him to ask a patient sitting on the edge of a table to extend his

In the nursing care of the patient particular attention should be paid to the condition of the skin to prevent bed sores or chafing from the splints A daily sponge bath may be given, followed by a light alcohol rub but the sensitive joints should be moved as little as possible and no brisk rubbing should be given with the alcohol. Any deep massage or too much passive motion, may increase the sensitiveness and prolong this stage

If the limbs are completely immobilized for any length of time in the corrected position, the sensitive muscles will shorten in this position, and joint motion will be lost Light passive motion of the knees and hips should be given twice daily flexing each to the point of pain once or twice. Otherwise when active treatment is started, it will be found that the patient can not be sat up on a chair because of the tightness of the posterior gluteal muscles at the hip, and the knees can not be bent on account of the tight knee extensors which can not be easily stretched out without permanent damage to the muscles. The joints of the arm should be treated in the same way

The general practitioner can prevent deformities and hold the legs and trunk in their normal position by means of sandbags, or a box to hold the feet at right angles with the body kept in a straight position by pillows A patient with sensitive shoulders should not be allowed to keep the arms close to the chest and the elbows flexed. A small pillow in the axilla will help to prevent adduction contractures if a splint is not available and a bandage around the wrist may be pinned to the bed to keep the elbow in partial extension.

It is far better to utilize pillows even though they must be adjusted frequently to maintain the desired position than it is to put on a solid plaster cast and leave the patient in it for any length of time. This interferes with the return of muscle power and produces stiff joints.

Rest is the essential thing during this period and the patients should be moved as little as possible except for necessary nursing care a Bradford frame should be used if it is necessary to carry them. No increase in muscle activity should be allowed before a muscle examination is made.

Third or Convalescent Stage

When the sensitive stage is over active physical therapy can be started.

At this time an examination shows either a definite flaccid paralysis of the muscles affected or if a mild case some degree of weakness. The reflexes may or may not be present, according to the extent of the damage in the spinal cord but they are never increased in this stage Some muscles may be contracted from overbalance or from habitual position but they are never spastic. The patient s coördination in controlling the muscle power which remains is never affected. If he has the muscular strength to perform the desired motion, he will execute it, and there will be no ataxic or uncoördinated movements.

The mentality is never impaired and as a general rule the patient's attitude is hopeful and coöperative, although some of the older ones may have more or less depression as they come to realize the extent of their affliction.

The circulation of both legs is decreased during the period while the patient is being kept in recumbency and atrophy will follow if the circulation is not kept up Besides this effect of inactivity on the circulation of both normal and affected muscles there is in many cases some vasomotor disturbance which shuts down the blood supply to a great degree As a result of this we may find later a marked atrophy of the muscles and considerable shortening in a leg where there is very little loss of power while another case with marked muscular involvement may have no shortening at all. However the majority of cases with severe leg paralysis eventually show both atrophy and shortening

While some cases may show some loss of sensation during the acute stage and a few have incontinence or retention of urine these symptoms are never permanent and if present, are a sign of some condition other than infantile paralysis

The classic signs of some other forms of paralysis such as shiny skin deformed nails lack of sensation or anesthesia to heat pain touch etc. are never present in infantile paralysis

This period when the sensitiveness has recently disappeared is the period of most rapid spontaneous recovery Many cases show a remarkable spontaneous recovery in power during the first few weeks after the onset even changing from complete paralysis to normal strength without any treatment whatever This is explained by the fact that the early paralysis was due to pressure on the nerve centers by the edema in the spinal cord without however any destruction of these motor centers With the disappearance of the edema the nerve cells resumed their normal function and the muscles ceased to be paralyzed. This spontaneous recovery is often attributed by parents and irregular practitioners to all sorts of batteries lights and applications which have no value in themselves

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HARVARD INFANTILE PARALYSIS COMMISSION

300 LONGWOOD AVENUE, BOSTON

Number Date Clinic

Age

Name Sex Birthday

Residence Telephone

Birthplace

Race

Father's Name Birthplace Occupation

Mother's Name Birthplace Occupation

Doctor's Name Address

Date of Onset Date of Paralysis

Serum Initial Symptoms

Distribution of Initial Paralysis

Sensitiveness (where)

Previous Treatment

Operation

FIG. 5.—History sheet used in the After-Care Treatment Clinic of the Harvard Infantile Paralysis Commission.

HARVARD INFANTILE PARALYSIS COMMISSION

No.

Patient's Name

Left Arm		Right Arm
	Contractions and Deformities	
	Shoulder	
	Elbow	
	Wrist	
	Fingers	
	Anterior Deltoid	
	Posterior Deltoid	
	Upper Trapezius	
	Middle Trapezius	
	Lower Trapezius	
	Serratus Magnus	
	Rhomboids	
	Latissimus Dorsi	
	Clav. Pect. Major	
	Stern. Pect. Major	
	Outward Rotators	
	Biceps	
	Triceps	
	Supin. Brev.	
	Pronators	
	Flexor Carpi Rad.	
	Flexor Carpi Uln.	
	Extensor Carpi Rad.	
	Extensor Carpi Uln.	
	Flex. Prof. Digit.	
	Flex. Sub. Digit.	
	Finger Ext.	
	Lumbricales	
	Dors. Inteross.	
	Abd. Min. Digit.	
	Palm. Inteross.	
	Oppon. Poll.	
	Abd. Poll.	
	Thumb Flex.	
	Thumb Ext.	
	Upper Arm	
	Lower Arm	

FIG. 6.—Arm Examination Sheet used in the After Care Treatment Clinic of the Harvard Infantile Paralysis Commission.

HARVARD INFANTILE PARALYSIS COMMISSION

300 LONGWOOD AVENUE, BOSTON

Number	Date	Clinic

			Age
Name		Sex	Birthday
Residence		Telephone	
		Birthplace	
		Race	
Father's Name	Birthplace	Occupation	
Mother's Name	Birthplace	Occupation	
Doctor's Name		Address	
Date of Onset		Date of Paralysis	
Serum	Initial Symptoms		

Distribution of Initial Paralysis

Sensitiveness (where)

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Operation

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No

Patient's Name

Left Arm		Right Arm
	Contractions and Deformities	
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	Wrist	
	Fingers	
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	Posterior Deltoid	
	Upper Trapezius	
	Middle Trapezius	
	Lower Trapezius	
	Serratus Magnus	
	Rhomboids	
	Latissimus Dorsi	
	Clav. Pect. Maj	
	Stern. Pect. Major	
	Outward Rotators	
	Biceps	
	Triceps	
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	Flex. Carpi Rad.	
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	Abd. Min. Digit.	
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	Oppon. Poll.	
	Abd. Poll.	
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	Thumb Ext.	
	Upper Arm	
	Lower Arm	

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300 LONGWOOD AVENUE, BOSTON

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	Abd. Poll.	
	Thumb Flex.	
	Thumb Ext.	
	Upper Arm	
	Lower Arm	

FIG. 6.—Arm examination sheet used in the After Care Treatment Clinic f the Harvard Infantile Paralysis Commission.

No.

Patient's Name

Cannot walk, walks unaided with braces, crutches and corset.

Characteristic Gait

Scoliosis

Left Leg	Contractions and Deformities	Right Leg
	Hip	
	Knee	
	Ankle	
	Facial — Orbit	
	Facial — Mouth	
	Anterior Neck	
	Posterior Neck	
	Back	
	Respiration	
	Quadratus Lumborum	
	Anterior Abdominals	
	Lateral Abdominals	
	Gluteus maximus	
	Hip Flexors	
	Sartorius	
	Inward Rotation	
	Outward Rotation	
	Tensor Fasciae Latae	
	Hip Abductors	
	Hip Adductors	
	Quadriceps	
	Inner Hamstrings	
	Outer Hamstrings	
	Gastrocnemius	
	Anterior Tibial	
	Posterio Tibial	
	Peroneals	
	Extensor Longus Digitorum	
	Extensor Proprius Hallucis	
	Flexor Longus Digitorum	
	Short Toe Flexors	
	Flexor Longus Hallucis	
	Length	
	Thigh	
	Calf	

FIG. 7.—Leg examination sheet used in the After-Care Treatment Clinic of the Harvard Infantile Paralysis Commission.

knee and pronounce that his muscles are gone if he is unable to do so A knowledge of an easier position in which the weakened muscle can function may demonstrate a considerable amount of power remaining and may entirely change the prognosis as well as the treatment to be advised On the other hand it should be remembered that normal muscles not only produce movement through a certain arc of motion

FIG. 8.—Equinus—assumed with child sitting with weak dorsiflexors.

but are able to do so against a considerable degree of resistance and to hold the part in that position against a considerable amount of outside pressure It is not safe to assert that a child has no weakness because he is able to move his arms and his legs about in bed Partial paralysis is more common than total and the presence of enough unparalyzed fibers in a muscle to straighten the knee in bed or sitting up does not prove that there are enough unaffected fibers in that muscle to hold the patient's weight in standing

HARVARD INFANTILE PARALYSIS COMMISSION

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Patient's Name

Cannot walk, walks unaided, with braces, crutches and corset.

Characteristic Gait

Scoliosis

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	Hip	
	Knee	
	Ankle	
	Facial Orbit	
	Mouth	
	Anterior Neck	
	Posterior Neck	
	Back	
	Respiration	
	Quadratus Lumborum	
	Anterior Abdominals	
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	Calf	

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No

Patient's Name

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Characteristic Gait

Scoliosis

Left Leg	Contractions and Deformities	Right Leg
	Hip	
	Knee	
	Ankle	
	Facial Orbit	
	Mouth	
	Anterior Neck	
	Posterior Neck	
	Back	
	Respiration	
	Quadratus Lumborum	
	Anterior Abdominals	
	Lateral Abdominals	
	Gluteus maximus	
	Hip Flexors	
	Sartorius	
	Inward Rotation	
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	Tensor Fasciae Latae	
	Hip Abductors	
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	Outer Hamstrings	
	Gastrocnemius	
	Anterior Tibial	
	Posterior Tibial	
	Peroneals	
	Extensor Longus Digitorum	
	Extensor Proprius Hallucis	
	Flexor Longus Digitorum	
	Short Toe Flexors	
	Flexo Longus Hallucis	
	Length	
	Thigh	
	Calf	

FIG. 7.—Leg examination sheet used in the After Care Treatment Clinic of the Harvard Infantile Paralysis Commission.

Equinus—If a shortened tendo achillis prevents the heel from touching the floor so that the weight is borne wholly on the forefoot, the condition is called an equinus

Valgus—If the adductors the muscles which invert the foot, are the only weak muscles the stronger abductor group the peroneals will pull the foot out into eversion (valgus) The patient will walk with the foot displaced outward and the internal malleolus will appear prominent. An equinus may also be present, in which case the deformity is called equinovalgus and the weight is borne on the toes with the foot displaced outward.

FIG. 0.—Equinovarus deformity due to weak dorsiflexors and peroneal group

Varus—When the abductor group which everts the foot is weak and the invertors are strong the foot is turned in so that the weight is borne on the outer border of the foot This deformity is called varus. It is frequently combined with an equinus.

Should all three of these groups be weakened strength in the posterior calf group would still produce an equinus on account of the weakness of dorsiflexors but the foot would not be displaced to either side if the invertors and the evertors were equally weak

Calcaneus—Weakness of the gastrocnemius and soleus when the opposing dorsiflexors are strong results in a gait without spring The weight is borne heavily on the heel and the heel cord gradually becomes stretched out This condition is known as calcaneus

The details of making a complete muscle examination will be found in the later section on muscle training

After the muscle examination if the patient has been allowed to walk it is very important to notice the weight bearing position of his feet knees and trunk as well as any fixed deformities which he may have acquired The gait should also be analyzed very carefully

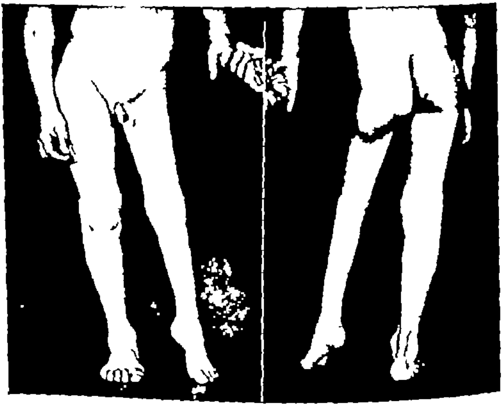

FIG. 9.—Equinus with tight heel cord

A form like the following may be of assistance

FEET (a) Do they turn out?
(b) Are they rolled in the weight being borne on the outer border?
(c) Is there a foot drop—does he walk wholly on his toes?
(d) Does the weight come heavily on the heel without spring?

KNEES (a) Are they locked back in hyperextension on weight bearing?
(b) Are they kept flexed at all times?

TRUNK (a) Is the trunk carried forward and the hip permanently flexed?
(b) Is there a lateral curvature of the spine?
(c) Is the pelvis tilted down on one side?
(d) Does the patient stand with prominent abdomen and lordosis?

GAIT Much can be learned from studying the gaits.

Toe drop—If the anterior dorsiflexor muscles of the lower leg are much weakened there will be a toe drop The knee will be lifted high in taking a step in order to have the toes clear the floor

Equinus—If a shortened tendo achillis prevents the heel from touching the floor so that the weight is borne wholly on the forefoot, the condition is called an equinus

Valgus—If the adductors the muscles which invert the foot, are the only weak muscles the stronger abductor group the peroneals will pull the foot out into eversion (valgus) The patient will walk with the foot displaced outward and the internal malleolus will appear prominent An equinus may also be present in which case the deformity is called equinovalgus and the weight is borne on the toes with the foot displaced outward.

FIG. 10—Equinovarus deformity due to weak dorsiflexors and peroneal group.

Varus—When the abductor group which everts the foot is weak and the invertors are strong the foot is turned in so that the weight is borne on the outer border of the foot This deformity is called varus It is frequently combined with an equinus

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Calcaneovarus—Greater strength in either the invertors or the evertors may cause a varus or a valgus in addition to the calcaneus.

Flail—A flail foot without fixed deformity results when there is severe paralysis of all the muscles of the lower leg since no one group is strong enough to overbalance its opponent In walking a patient with a flail foot comes heavily on his heel and has a foot drop as well, when the foot is clear of the floor A flail foot may be turned either out or in when weight bearing but is not fixed in any position

FIG. 11 —Valgus deformity due to weak adductor or tibial group.

Forefoot varus—A valgus foot or a flail foot may show varus of the forefoot if the plantar fascia is sufficiently contracted without any change in the position of the os calcis.

Knee—The position of the knee in weight bearing should be noticed next, for hyperextension is very common The function of the quadriceps extensor muscle is to keep the knee stiff in weight bearing *If* this muscle is weak there is constant danger of having the knee bend under the body weight, thus causing a fall There are various ways in which a patient with a weak quadriceps may walk to lessen this danger The common way is to keep the weight of the body in front of the center of the knee joint when standing on that leg This may be accomplished

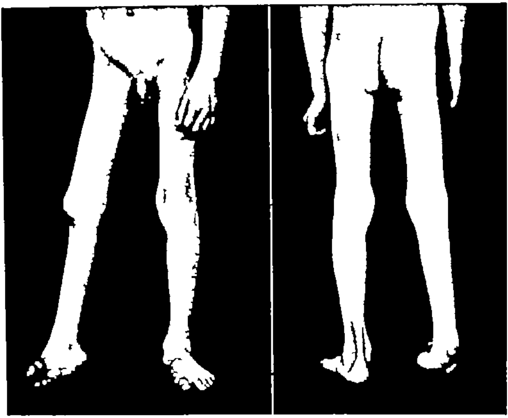


Fig. —Varus deformity due to weak peroneal group.

Fig. 13.—Calcaneus deformity from weak gastrocnemius and unparalyzed dorsiflexors (Lovett.)

Fig. 14.—Hyperextended knees due to allowing weight bearing without support. (Lovett.)

by bending slightly forward and using the hand to press the thigh back each time the weight is taken on that leg This locks the knee joint against flexion Many patients accomplish this locking of the knee back in hyperextension without using the hand, by carrying the body ahead of the leg This locking of the knee back in hyperextension is a severe strain on the posterior structures of the knee joint. If there is any considerable degree of weakness in the muscles which reënforce the knee joint posteriorly, either the hamstrings or the gastrocnemius, the knee is forced back into a greater degree of hyperextension than a normal joint will allow and the joint capsule becomes permanently stretched Extreme cases even present a backward bowleg. Once this deformity has developed it is practically impossible to correct it even

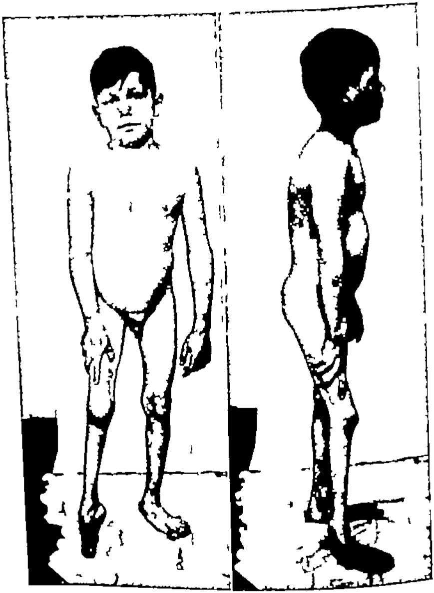


Fig 5—Hand supporting thigh in standing with weak quadriceps.

though the quadriceps muscle may grow stronger and the position is a potential cause of painful joint strain in later years, as well as a permanently awkward gait A strong quadriceps may cause hyperextension of the knee in the presence of weak posterior muscles but the mechanical locking of the knee necessitated by a weak quadriceps is a more frequent cause.

Another gait which is sometimes developed by the individual with a weak quadriceps is that of walking with the whole leg rotated out. The internal lateral ligaments of the knee take the strain in this case without locking the knee back. Efforts to train such a patient to walk with his foot and leg pointed forward will only result in increased falls, if his knee is not held by a brace.

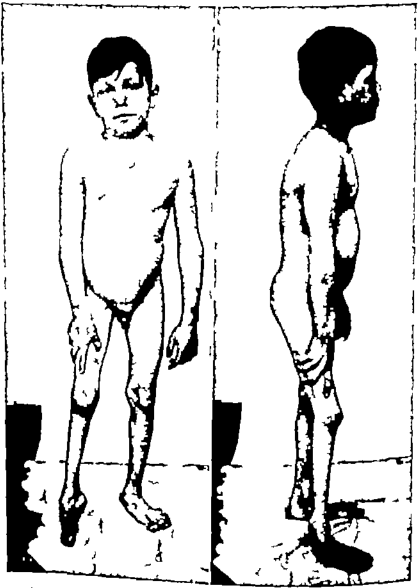
A knee flexion contracture may cause walking with the knee bent

The limps which are caused by weakness of the gluteal muscles are very awkward and noticeable It is important to recognize them since they are not usually improved by braces or by operations on the feet, and much disappointment will be avoided if this is explained to patients before undertaking measures which may improve the lower joints

The function of the gluteal muscles in standing is to hold the pelvis in position over the leg which is taking the body weight at the moment When the weight is taken on the left leg for instance the left gluteus maximus posteriorly tightens to prevent the pelvis from tipping forward so much that the erect position of the trunk will be lost. If this muscle is too weak to hold the pelvis back in place the patient must either support himself with a crutch or a cane in front to prevent flexion from occurring at the hip or else he must throw his trunk backward at the moment of stepping on the left leg by so doing the superincumbent weight of the trunk is brought behind the center of motion of the hip joint and the danger of flexing the hip is prevented This throwing of the body backward each time the patient steps on one of the legs is a definite sign of weakness of the gluteus maximus of that side If the gluteus maximus of both sides is poor the patient may walk without crutches provided the knees are held in extension by carrying his trunk posterior to his legs the abdomen usually protruding Efforts to teach him to stand with his weight forward only result in his sitting down backward unless crutches are substituted to hold him up

Weakness of the left gluteus medius usually results in a throwing or bending of the trunk to the left side whenever the right foot is taken off the floor When the support of the right leg is removed the pelvis tends to drop down on the right side unless it is held by the left gluteus medius from doing so or unless the trunk is tipped far enough over to the left to raise the right side of the pelvis This tipping of the body to the weak side is the common abductor limp and it is sometimes difficult to distinguish from a short leg limp Occasionally instead of tipping to the weak side the opposite side of the pelvis is allowed to drop in a limp similar to a mild Trendelenburg sign. Weak

by bending slightly forward and using the hand to press the thigh back each time the weight is taken on that leg This locks the knee joint against flexion Many patients accomplish this locking of the knee back in hyperextension without using the hand by carrying the body ahead of the leg This locking of the knee back in hyperextension is a severe strain on the posterior structures of the knee joint. If there is any considerable degree of weakness in the muscles which reenforce the knee joint posteriorly, either the hamstrings or the gastrocnemius, the knee is forced back into a greater degree of hyperextension than a normal joint will allow and the joint capsule becomes permanently stretched Extreme cases even present a backward bowleg. Once this deformity has developed, it is practically impossible to correct it even



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ness of the abductors of both hips results in a waddle, tipping from side to side

Weakness of both the gluteus medius and the gluteus maximus, hip abductor and extensor, on the same side, causes the body to be tipped diagonally back on the weak side

Marked weakness of the hip flexors makes it difficult to move the leg straight forward and this is usually overcome by a slight twist of the pelvis which brings the leg forward usually in outward rotation.

FIG. 16—Lumbar lordosis due to hip contraction.

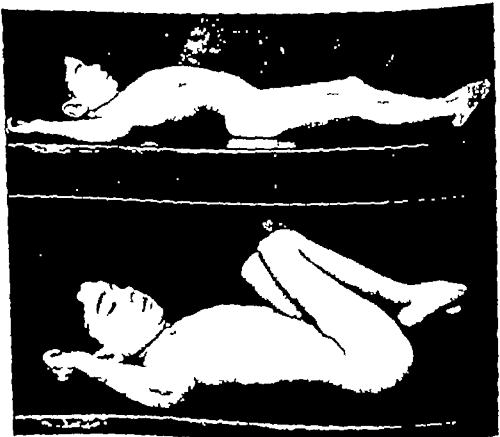

FIG 17—Case showing marked lumbar lordosis due to hip contraction.

FIG. 18.—Bulging abdomen when crying—right lateral abdominal weakness. (Lovett.)

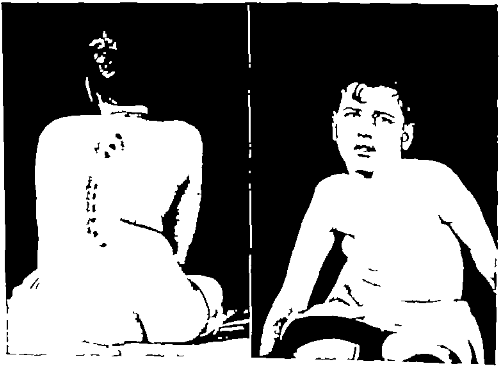

FIG. 19.—Marked scoliosis with rotation from lack of adequate treatment.

ness of the abductors of both hips results in a waddle, tipping from side to side

Weakness of both the gluteus medius and the gluteus maximus, hip abductor and extensor on the same side, causes the body to be tipped diagonally back on the weak side

Marked weakness of the hip flexors makes it difficult to move the leg straight forward, and this is usually overcome by a slight twist of the pelvis which brings the leg forward usually in outward rotation

FIG. 16 — Lumbar lordosis due to hip contraction.

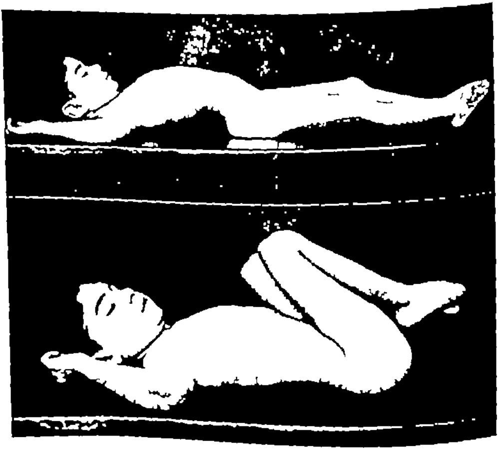

FIG 17 — Case showing marked lumbar lordosis due to hip contraction.

FIG. 18.—Bulging abdomen when crying—right lateral abdominal weakness. (Lovett.)

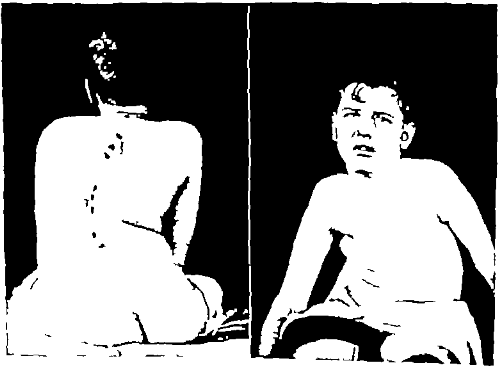

FIG. 19.—Marked scoliosis with rotation from lack of adequate treatment.

Shortening and abdominal paralysis also complicate the hip limps, and habit forms a very considerable element in the limp of a chronic patient

If a child with weak hip extensors has been allowed to sit up a great deal with the hips flexed, it will be found that the hips are held per

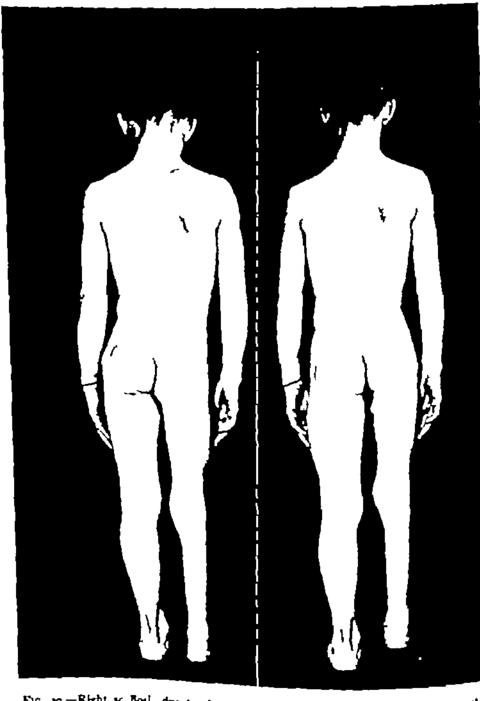

Fig 10—Right sc Bol due to short leg. Correction f same by equalizing length.

manently flexed when the time comes for the child to stand This necessitates an increase in the normal physiologic curve of the lumbar spine in order to hold the body erect—in other words a lordosis

The patient with weak anterior abdominal muscles stands with a very prominent abdomen and often has the same tendency to arch the back.

Weakness in the lateral abdominal muscles usually results in standing or sitting with a list toward the stronger side and a curvature in the spine This is functional at first and very flexible but if not properly supported may increase in severity very rapidly Length of the legs involvement of the shoulder chest and back muscles, and efforts at maintaining equilibrium all play a part in determining the type of scoliosis which results

Besides this detailed muscle examination and a recognition of any existing deformities or limp the physician should inquire into other points which will be helpful in formulating an adequate plan of treatment If the patient has been allowed to walk questioning will often bring out the facts that he limps more when he is tired or that he has trouble going up the stairs The question of whether or not a slight case should go back to school may depend on these points and the distance he will have to walk, or the number of stairs to be climbed There may have been no apparent trouble with the arms during the acute stage yet some weeks afterward it may be noticed that continued effort in writing or sewing causes undue fatigue and that the hand is used awkwardly Inability to cough normally and clear the throat, difficulty in swallowing dry or solid food and an unusually nasal voice are important points which may not be brought out in the muscle examination A nervous irritability is frequently noticed in children who have been allowed to resume their normal activities too soon.

OUTLINE OF TREATMENT

The treatment to be advised at this time should still lay emphasis on the prevention of fatigue and of deformities This is also the time above all others to concentrate on measures to reeducate the muscles and to develop strength whenever response can be obtained

All parents are anxious to get the child to sit up and be on his feet as quickly as possible It is difficult to explain to them that sitting up and walking are the worst things that the child can be allowed to do if his muscles are not strong enough to hold his body in the normal position. This is because faulty position puts the weakened muscles on the stretch and they become fatigued from trying to work under a disadvantage Stretching and fatigue make it more difficult for them to regain their strength and their chance of recovery is definitely lessened Habitual weight bearing in a deformed position results in a permanent deformity Even though the muscles may gradually become somewhat stronger displaced bones and stretched ligaments do not

return to normal, and hyperextended knees, scoliosis and foot deformities do not disappear

If the legs are not involved, there is no reason why a patient should not be allowed to walk when the sensitive stage is over, provided that the trunk is properly supported if it is weak and the arms are held in abduction if the deltoids are weak

If there is even slight weakness of the legs, weight bearing and walking should be forbidden at this time

It has been my routine to forbid walking and weight bearing in cases of slight leg involvement, until the muscles have regained their normal power Even then one must be careful in guarding against muscle fatigue Muscles which have been weakened by poliomyelitis, fatigue much more quickly than normal, even though their strength appears normal while undergoing manual tests

If the legs are markedly involved, it has been my routine to prevent weight bearing for six or nine months if the muscles continue to show improvement under treatment, in order that the gain may not be checked by over-use. During this period, muscle recovery should be aided by daily massage to improve nutrition, and carefully carried out muscle training to strengthen the weakened muscles If walking is not permitted, this treatment should be extended to include a normal leg in order to keep up its muscle tone. When the circulation is badly affected, it is well to employ some form of heat before the massage Stimulation by electricity in any form at the present time has no place in the treatment of infantile paralysis, to my mind

Cases with considerable involvement of the legs should continue to wear the posterior wire splints applied during the earlier stage. It is important however that these splints should be removed twice a day and that as much motion as is possible without pain should be carried out in all the joints Great care should be used in flexing the knee if the quadriceps has become tight from too long immobilization on the splint as it is not uncommon to find definite trauma of the muscle when too much force is used

Operative measures are not indicated at this time. It is not always necessary to wait two years before proceeding with operative measures as the tradition has been handed down, but it is my belief that we should wait at least a year before doing transplantations or other operations in an attempt to reestablish muscle balance. At the end of a year a surgeon who has watched a case from the beginning will know fairly definitely how much more progress is likely to be made in regaining power under physical therapy treatment. In the case of marked contractures which have occurred from lack of early care radical treatment should be instituted at any time before the end of a year if splints and manual stretching are found inadequate to overcome the deformities No marked deformities

should ever occur in cases of poliomyelitis if efficient treatment has been advised and carried out from the start

It is inexcusable to allow a case to go without receiving all possible benefits from muscle training and the prevention of deformity because the surgeon thinks that operative measures will be needed in the future It is impossible to foretell at the start how much improvement can be obtained with treatment. Furthermore, the bony changes which take place when a deformity is neglected make a good end result less likely A patient is entitled to his chance of regaining as much power as possible under other forms of treatment before operative measures are considered

The Fourth or Chronic Stage

The exact time when a case becomes chronic does not depend as much upon the number of months after the onset of the disease as upon the time when its condition seems to be about stationary The time of spontaneous improvement and of rapid gain under treatment is over and it is obvious which muscles will always be badly weakened although some further gain can usually be expected if treatment is continued. Deformities from lack of care, or from unequal balance, have become fixed the affected limbs are definitely atrophied and shortening has taken place.

It may be said that most of the spontaneous recovery will occur in three or four weeks It may also be said that the most rapid gain under muscle training will be made in the first nine months to a year as a general rule

There are however many instances where a muscle does not show any particular gain for many months after the onset and later shows marked improvement. This is generally due to the fact that the muscle was allowed to be on the stretch as in the case of a deltoid when the arm is allowed to hang by the side or in other instances where a muscle is outpulled by its stronger antagonist. Faulty weight bearing may also put weakened muscles on the stretch.

It can be asserted that no weak muscle will come back if it is allowed to remain on the stretch, but it is difficult to foretell which of these stretched muscles may recover if given a period of rest and reeducation with the strain removed Certainly they are entitled to the chance for there are numerous instances on record where poor muscles have regained good function after months of remaining at a standstill. One patient G S received no treatment for a poor deltoid for ten months after the onset, at which time muscle training was started A platform splint was applied one year after the onset. The poor deltoid showed no change during the first eight months of treatment, but in the next six months it improved to a "good" rating 2 5/12 years after the onset and 1 5/12 years after treatment was started.

Fig. —Frame for instruction in walking for severe involvement of legs and trunk.

No physician will ever see a case of infantile paralysis for the first time without being asked what the outcome is going to be It is a difficult question to answer at the first examination.

The parents can be told that some power will be regained in those muscles which are only weakened but it is impossible to say just how much at this time No prognosis can be made about the muscles which appear to be completely paralyzed except that about 50 per cent of completely paralyzed muscles do regain some power some of them even recovering normal strength if properly treated

As to the general outlook for the patient it is well to keep in mind that practically every patient will show some improvement under proper treatment, and that it is impossible to tell how much until it has been tried It can always be said that a patient with good arms can be made to walk with the help of braces and crutches even if both legs are useless and many patients with badly weakened arms and trunk in addition to helpless legs can be taught to walk for short distances in apparatus If serious deformities are prevented there should not be more than a few patients out of any thousand cases of infantile paralysis who are too badly paralyzed to be taught to walk with apparatus

A person without experience with large numbers of cases will do well to avoid the mistake of telling a patient that he can never walk again for the probabilities are that the statement is not true and the effect is to discourage any effort toward recovery

As has been said before it can be told rather definitely at the end of a year what permanent inequality of muscle balance about a joint is going to exist. So at this time tendon transplantations to reëstablish an even balance of power about a joint may be considered for the improvement of function Among the most common transplantations used in the foot are the following

1 Setting the tendon of a peroneal or an anterior tibial muscle forward into the dorsum of the foot to strengthen dorsiflexion in cases of equinus

2 Setting the tendon of the peroneus longus in the inner side of the foot when weakness of the tibial muscles allows strong peroneals to hold the foot in valgus

3 Setting the anterior tibial tendon to the outer side of the foot when there is weakness of the peroneals and a tendency to varus position on account of greater tibial strength

4 Setting the peroneals posterior tibial and sometimes the long toe flexors also directly into the os calcis to give them a stronger pull in plantar flexion when the gastrocnemius and soleus weakness has allowed a calcaneus to develop

There are other combinations used but no rules can be laid down because all transplantation operations must depend on the relative strength of the different muscle groups affected by the operation.

FIG. 21.—Frame for instruction in walking for severe involvement of legs and trunk.

to improve the function of the shoulder are of little use if there is no power to use the hand or elbow

Apparatus

Apparatus has two purposes in the treatment of infantile paralysis—to allow locomotion and to prevent or correct deformity

Provided that a child is making satisfactory gain under muscle training, it is our policy to keep him off his feet as long as possible

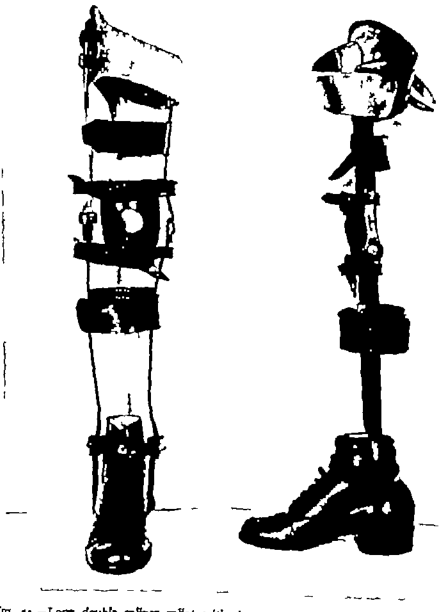

Fig 11.—Long double calliper splint with drop catch at knee and flange t heel to prevent toe drop.

After transplantation the muscle must be reëducated to take on its new function and must be protected from fatigue, stretching and faulty weight bearing as carefully as any weak muscle.

The success of the operation depends largely upon a proper estimate of the strength of the opposing muscle groups. Muscles of less than fair powers do not as a rule, function successfully in a new position On the other hand the transplantation of a strong muscle may so weaken the strength of its original group that overcorrection results in the production of a second deformity, the reverse of the original one.

Various transplantations may also be done at the knee and hip to improve function provide greater stability for the joint, or lessen limps. The function of the thumb hand and elbow may sometimes be improved by transplantations Those done at the shoulder have not been particularly successful

Besides tendon transplantations, bone stabilizations must be done in many cases The object of a stabilization operation is to destroy motion between certain bones so that they will be joined together in the correct position by bony union This operation is required when fixed deformities have occurred on account of inefficient early treatment which has allowed bony changes to take place and the articulating relation between bones has been changed Corrective operations may then have to be performed to replace the part in normal position as well as stabilization to hold it in place under weight bearing

In these cases the after treatment must be entirely different from that when transplantations alone have been done, because destroying mobility in certain directions also prevents the action of certain muscles. Very often the stronger muscles are utilized by transplanting them at the time of the stabilization so that they can assist in the action of the remaining joints

Arthrodesis of the shoulder joint is an operation which destroys all motion in the joint and unites the humerus with the scapula. It may give the patient better use of his arm provided that the muscles controlling the scapula are strong and that he already has good function in his hand and the ability to flex his elbow in at least half supination.

The age at which a bony operation should be performed must be left to the judgment of the surgeon. Lack of firm union or disturbance of growth from injury to the epiphysial centers may follow if done at too early an age.

The question of bone lengthening should be discussed with any patient who has more than two inches of shortening in a leg

The practical value of any operation should be carefully estimated before it is advised The objects should be to correct deformity to improve stability and lessen the amount of apparatus needed or definitely to improve function when other means have failed. Operations

to improve the function of the shoulder are of little use if there is no power to use the hand or elbow

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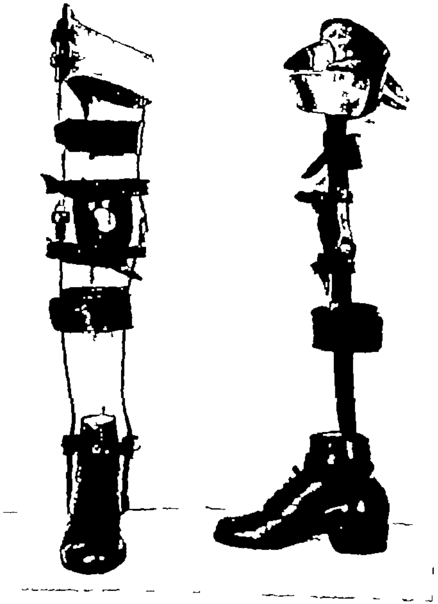

FIG. 2—Long double calliper splint with drop catch at knee and flange at heel to prevent toe drop.

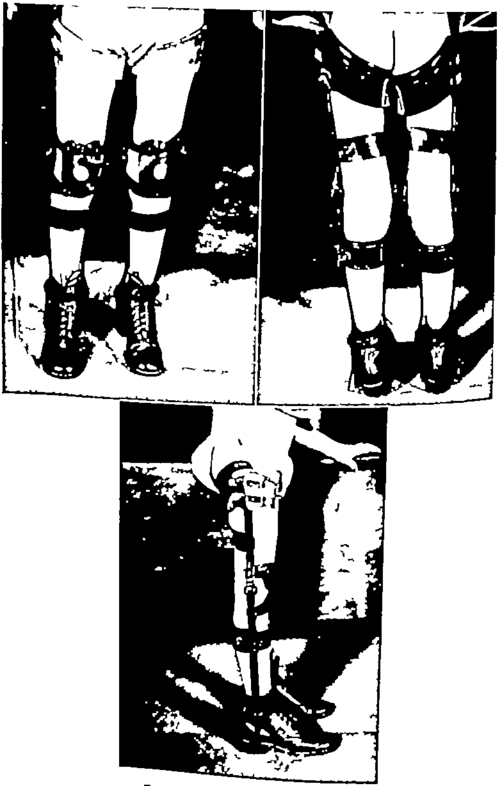

FIG. 23.—Double long callipers applied.

even though he may have fair power in his legs It is not good policy to continue this restriction indefinitely on account of the general condition however and most patients with any severe involvement of the legs start walking before it is advisable for them to do so without support. Many other patients in clinic practice cannot be kept off their feet even though they would benefit more from the rest if it were possible

In any case after six or seven months it is generally advisable to allow getting up on the feet for the effect on the general condition and the morale even though the length of time daily may be restricted.

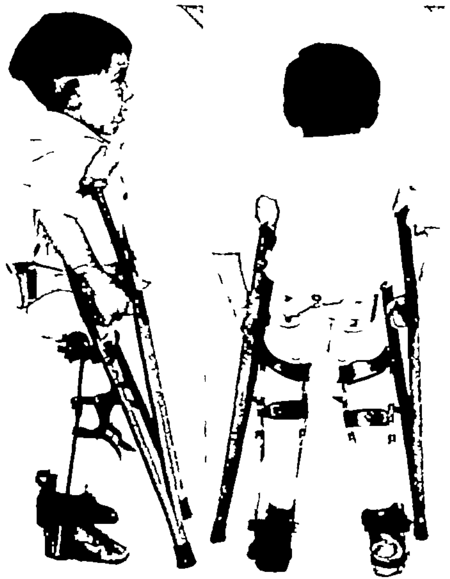

FIG. 24.—Sitting in braces. Position assumed where braces are too short.

Cases which have not been responding to treatment after six or seven months should also be started walking for the same reasons.

It is very important, however, that they should not be allowed to stand without supporting apparatus, if in so doing the knee, foot or leg is held in a deformed position If any marked degree of unequal

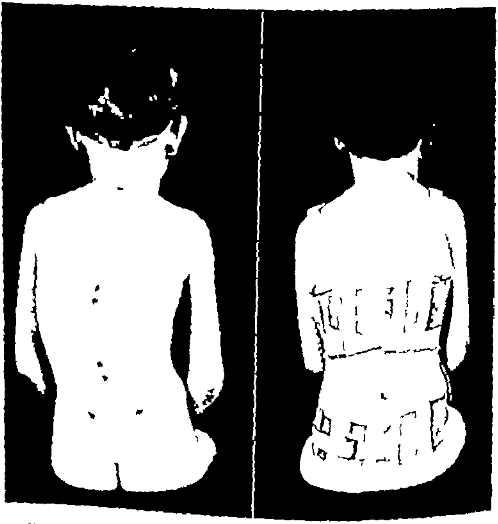

Fig. 15 —Early scoliosis due to weak abdominal muscles.

Fig. 15a —Same case as Fig. 15 with corrective canvas corset.

muscle balance exists weight bearing will cause the patient to stand in a deformed position will stretch out the weakened muscles and cause overfatigue with resultant loss of power and eventually bony deformity

Braces to prevent deformities of the foot may be of the caliper type or of the sole plate type

For calcaneus or equinus without lateral deformity of the foot, a simple caliper may be used with anterior or posterior flanges on the shoe socket to prevent dorsiflexion or foot drop as the case may be.

A sole-plate brace with straps or a leather anklet should be used to hold the foot in normal position if any lateral deformity exists. The ankle joint may be so constructed that it checks either dorsiflexion or foot drop according to the muscle balance.

FIG. 16.—Early scoliosis due to weak lateral abdominal muscles.

FIG. 16a.—Same case as Fig. 16 with corrective canvas corset with quadrilateral pad.

A high heel, either of cork inside the shoe or an elevation on the shoe itself, helps to take the strain off a weak gastrocnemius.

Tipping the shoe by an elevation of an eighth-inch to a quarter inch on the inner border of the heel helps to take the strain off the tibial muscles and correct pronation, and, if necessary, a leather inner sole with a felt pad under the arch can also be used with a caliper brace.

An elevation on the outer border of the heel, or of the sole of the shoe, will help to correct a tendency to roll the foot in.

Cases with weak quadriceps usually hyperextend the knee and require a long brace reaching to the groin with straps at the knee to prevent its flexing when weight is put upon it, and also to prevent its being thrown back into hyperextension. A knee joint to allow greater

FIG. 27.—Case showing deviation of head to left due to right involvement of lateral neck muscles.

FIG. 27a.—Thomas collar for correction of neck deviation.

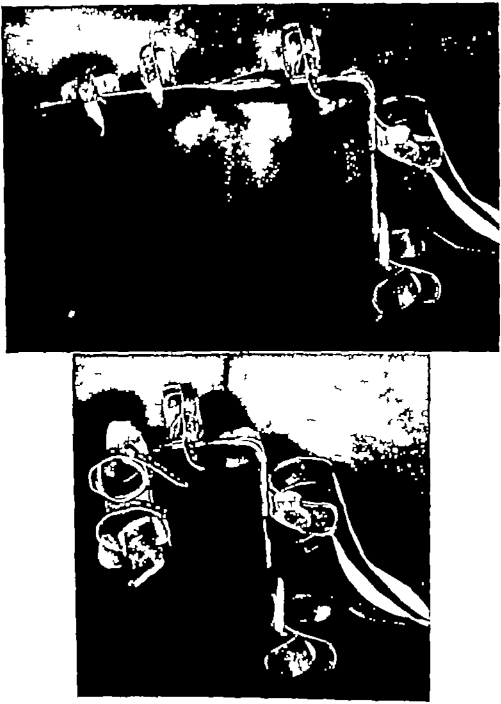

FIG. 8.—Arm abduction splint with elbow joint for use in deltoid paralysis.

comfort in sitting may be incorporated if the brace is built of flat metal, but should be locked in weight bearing

The lower end of the brace may have a foot plate or be of the caliper type, as required

Cases with weak abdominal muscles should have a stout, well-fitting corset made before they are allowed to sit up Weak trunk muscles allow the body to tip to the side, with danger of causing a scoliosis. The corset is also an aid in getting the balance on starting to walk as well as an agent to prevent deformity

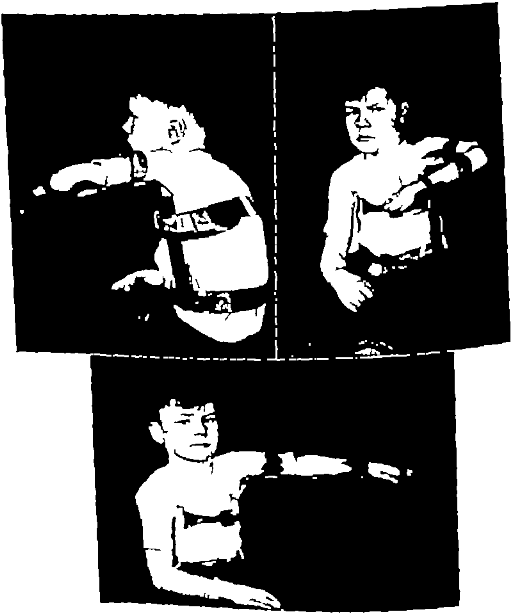

Fig. 9 Arm abduction splint applied with arm in flexion and extension.

In cases of severe weakness of the neck muscles a collar should be worn to keep the head in the normal position

Weakness of the deltoid muscle of the shoulder should be supported in abduction by a platform or aeroplane splint. If the arm is allowed to hang at the side this muscle will become stretched from the drag of the arm. A sling is not as beneficial because it favors the development of adduction contractures and does not hold the deltoid in the most

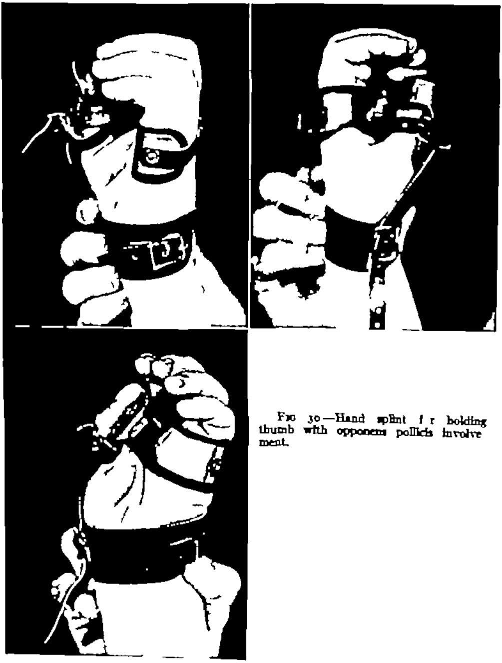

Fig 30 —Hand splint for holding thumb with opponens pollicis involvement.

favorable position for recovery The splint should be built with a joint at the elbow so that the forearm may be flexed if the biceps is weaker than the triceps, or held in extension if the triceps is weaker Free motion may be allowed if the elbow and hand muscles are good. It is desirable to have the forearm supported in neutral position halfway between flexion and extension rather than in full pronation.

A hand splint should be applied if there is lack of balance between the muscles at the wrist or in the hand

For useful hand function it is necessary to have the ability to grasp with the fingers flexing at all joints, with the wrist in some extension, and the thumb must be able to reach the finger tips. In building a splint for a hand with a weak thumb it is important to remember that the function of grasping things requires a thumb with its metacarpal bone nearly at a right angle to the palm of the hand in position for writing. The splint should be adapted to the muscle balance of the hand and at the same time consideration should be given as to whether a palmar or cock-up splint will most benefit the wrist.

These patients should not be sent to a brace-maker for whatever type of stock brace he sees fit to apply The doctor in charge of the case should decide what factors must be incorporated in the brace and must then supervise it personally to insure its doing the work desired.

Physical Therapy Treatment

Heat.—The application of some form of external heat should be included in the first part of the physical therapy treatment of any infantile paralysis patient whose muscles are extensively involved. Sluggish circulation and coldness of the affected extremities are commonly present and it is well known that muscles cannot perform their best work when they are cold It frequently happens that very weak muscles are unable to perform any movement whatever when they are cold so it is evident that more benefit will be received from the muscle training if the part is thoroughly warmed first. The increase of the circulation through the affected part resulting from the local application of heat is valuable in keeping up the nutrition of the muscle fibers and in hastening the removal of waste products

Heat may be applied in different ways The most common and simplest means is by the use of a baker which consists of a reflector and either a special radiant light bulb or some form of heating element which is supposed to be rich in the infra red wavelengths of the spectrum There seems to be no particular advantage from using these infra red bakers since the radiant light bulbs give off as much heat as the skin will tolerate and laboratory research seems to confirm the idea that visible light rays are more penetrating than infra red In choosing a radiant light baker care should be taken that it is so constructed that the rays do not come to a focus at a burning point, as is sometimes the case in some of the cheaper single bulb types. Larger

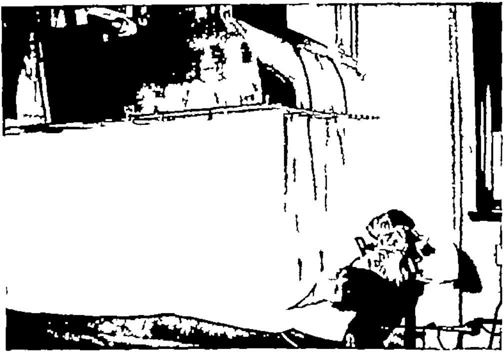

FIG. 31.—Large baker to accommodate a number of children.

FIG. 32.—Baker with curtain drawn back.

bakers holding a number of bulbs will be found more efficient for cases with extensive involvement. The hanging type shown can be lowered to the desired height above a table, over which is spread an electric blanket, and the three or four small children placed inside the curtains are thoroughly warmed all over in ten or fifteen minutes.

The writer believes that there is no advantage to be gained by the use of medical diathermy as a means of producing heat in the treatment of infantile paralysis, and there are practical disadvantages in cases of extensive paralysis on account of the length of time required. The danger of burns is also greater with small children. For home use, hot blankets can be used, if no other form of heat is available.

Massage.—The physiologic effects of massage are similar to those of heat, in that both increase the blood supply and keep up the metabolism. In addition, massage is a form of passive exercise or manipulation of muscles which tends to prevent adhesions in muscles which are not normally active. Massage is fatiguing if given for long periods of time or with much force in an effort to warm up cold extremities. The preliminary use of heat will be found to shorten the time required for massage and to increase the circulation without fatiguing the muscles. It should always be borne in mind that massage in itself does not increase muscle power, and that massage alone does not constitute adequate treatment of weakened muscles.

The technic of giving massage is also important, for if poorly or improperly given, harm rather than benefit will result.

The pressure should be very light in order not to bruise the weakened muscle fibers, and the muscle should be raised from the bone rather than flattened down on it. Only enough pressure to quicken the blood circulation is needed, and no benefit occurs from using greater force. The direction of the pressure should be the same as that of the venous circulation and should never work against it. Stroking and kneading are the two manipulations most helpful for the muscles, and friction may be employed around contractures in addition to the definite stretching of the contracted tendons. There seems to be danger of harming atrophied paralyzed muscle fibers by the various forms of percussion intended to stimulate nerves and muscle fibers by sharp blows. The greatest care should be taken to prevent tiring or bruising the atonic muscle fibers by too heavy handling. Massage is a passive manipulation of the tissues, which should leave them in better condition for the voluntary efforts at movement—the so-called active exercises—which are necessary to develop strength.

The author personally prefers the Hoffa technic of massage in the treatment of infantile paralysis because a point is made of taking the individual muscle group separately and following the direction of the muscle fibers with the stroke, which is always a continuous upward pressure from the distal to the proximal end.

Muscle Training *

By muscle training we mean the localized action of certain definite muscles or muscle groups—the attempt to exercise and develop certain muscles without at the same time bringing into play other muscles whose action is for some reason undesirable. The object is a more localized action than that involved in the so-called corrective, or individual gymnastics

Muscle training is especially useful in the treatment of infantile paralysis. Some years ago patients with weakened leg muscles were encouraged to be as active as possible the theory being that exercise strengthened the muscles Exercises were given to bring up the strength of the weakened leg without much thought being given to what particular muscles were performing the exercises or what degree of weakness existed in individual muscles The fact that fatigue increased the weakness in already weakened muscles was not considered nor that a patient always tends to perform a movement by using the strong muscles rather than the weakened ones

Some of the points in the physiology of muscles which have a practical bearing on muscle training are as follows

Each muscle is made up of many muscle fibers Action or contraction of a muscle makes the individual fibers shorter and thicker and causes a chemical action with resultant waste products These are normally removed by the circulation of the blood and fresh blood is brought back This is helped by the mechanical pumping action of the muscle fibers and joints on the blood vessels. If the circulation is not good there is an accumulation of waste products with a resulting loss of muscle power Exercises should be given in sufficiently slow rhythm and time enough allowed between counts for recovery of the muscle.

Dr Shepherd I. Franz in his book "Nervous and Mental Re-education" states that "the complex nervous adjustments are made not only at the time a special exercise is taken but also in the period of rest which follows one exercise and which precedes the next exercise" He also insists on the full arc of motion being made each time in order to get the full mechanical effect of the joint action on the circulation

The full arc of motion is also desirable in order to establish the habit reflex and obtain better coördination of the nerve centers through frequent repetition of a normal movement.

Passive movement is useless in restoring muscle power There must be attempted voluntary movement until active movement is achieved

A muscle can perform more work when the contraction is started from the stretched position than if the muscle is already partially

* The section on Muscle Training has been arranged by Miss Janet B Merrill, Director of Physical Therapeutics at the Children's Hospital, Boston, to whom I am greatly indebted for her assistance.

contracted as movement is started The muscles develop best when they are given all the work they can do without fatigue.

Beevor, in his lecture on "Muscular Movements and Their Representation in the Central Nervous System,' states that a muscle may take part in two different movements—for instance the biceps, which acts with the supinator brevis as a supinator, and also takes part with another group of muscles in flexion of the elbow He states that it is possible that if one of these movements be lost owing to an organic lesion of the central nervous system and not the other movement, the biceps which takes part in both movements, may be paralyzed for the one movement and not for the other

Whenever free exercises are given in the effort to strengthen any individual muscle other muscles are involuntarily contracted by the patient in the effort to localize the movement. Beevor explains synergic muscles as follows

When a muscle in passing over two or more joints has two or more different actions then if only one of these actions be required other muscles are brought into the movement whose actions are antagonistic to those of the muscles which are not required. The muscles which are brought into action to neutralize an action which is not required are called *synergic muscles* Example wrist flexors come into synergic action to prevent extension of wrist when extension of fingers alone is required The *antagonists* are the finger flexors which relax during the movement of finger extension

The general purposes of muscle training in poliomyelitis are

1 To maintain and improve the circulation and nutrition

2 To maintain muscle tone and prevent degeneration and atrophy of muscle fibers from disuse or from joint adhesions in cases where the motor nerve supply is partially or temporarily interrupted

3 To keep up tone in muscles whose nerve supply has been impaired during the period of recumbency or disuse

4 To coördinate the remaining nerve centers where partial destruction of the centers controlling a part has occurred—reëducation by habit—while at the same time developing the fibers of the muscle which are still functioning normally thus increasing the strength of the entire muscle

5 To develop coördination and control.

A study of the cases following the epidemic in Vermont, in 1914 brought out the need for systematizing the examination of weakened muscles and analyzing the exercises given for their treatment. This work was done by Miss W G Wright Dr Robert W Lovett's assistant. In 1916 the New York and Massachusetts victims of the epidemic were also treated under Dr Lovett's supervision by methods learned from the experience in Vermont.

The routine of examining and grading muscle strength and the positions used in giving exercises to the different muscles according to the amount of power found upon examination will be described according to the system in use in the Harvard Infantile Paralysis Commission Clinic at the Children s Hospital Boston The method is based upon the work of Dr Lovett and Miss Wright, as described in 'The Treatment of Infantile Paralysis by R. W Lovett.

It seems almost unnecessary to state that some system of grading muscle power is necessary in order to follow the progress of the different muscles under treatment Since we are working for the restoration of function it seems most natural to grade the strength of muscles according to their functional ability Then when we have clearly charted the relative functional strength of the different muscle groups it is an easy matter to pick out the exercise positions best suited to the amount of power found. No one would attempt to strengthen a child with normal muscles by asking him to perform some stunt entirely beyond his strength yet it is not uncommon to see infantile paralysis patients being urged to perform some exercise which is equally impossible for the partly paralyzed muscles This may have very serious results for several reasons In the cases of muscles so badly paralyzed that they can only start the movement, it often happens that after they have become fatigued by a number of efforts they can no longer even start the movement, and this loss of their previous ability may persist for several days There have been instances where returning power in the toes has been so damaged by over-use that it has been lost permanently

In other cases we see too hard an exercise position chosen which causes an attempt to reach the desired position by rotating the limb and substituting stronger muscles. This does not strengthen the muscles for which the exercise was intended.

Frequently the relative strength of opposing muscle groups is disregarded and we hear such remarks as 'No he can t push it down much, but he pulls it up fine so I let him do that, and then I put it down for him. In other words an exercise intended for the extensors has become an active exercise for the stronger flexor group and only passive motion for the extensors In this way the unequal balance of power about the point tends to become still more unequal as the stronger flexors increase in power under exercise and the extensors are neglected and the danger of producing a deformity due to unequal pull becomes steadily greater

The general rules for muscle training are

1 Avoid overfatiguing a muscle by overtreatment, by performing a movement rapidly or too many times.

2 Make each movement a voluntary active one performed by the patient in response to a stimulus If no power is present, the patient should attempt the motion with concentration while the operator

carries out the motion "with help" The patient should be instructed not to return the part to the starting position, but to relax after each effort and allow the operator to do the return movement passively

3 See that the full arc of the motion is obtained each time. If necessary, help should be given in completing the arc being careful to allow no pause at the point where the patient's strength gives out.

4. Localize the exercise by fixing the adjoining parts of the body so they will not take part in the movement. This is both to insure maximum concentration and effort in the desired action, and also to prevent substitution of other muscles It is better to give one movement at a time than a combined movement of two parts at the same time and if it is desired to give both flexion and extension exercises to the same joint, it is better to give them as two exercises with a rest between rather than have the patient attempt to exert his maximum effort during both parts of the exercises. Passive replacement of the part gives a chance for recovery before the next effort.

5 Give resistance to develop strength wherever possible. It should not be given until the muscle is able to complete the arc of motion unaided and if given it should always be a little less than that which would stop the movement or make it jerky, and should be graduated to leverage throughout.

6 Radiant heat with massage is desirable before the treatment is given to start the circulation and make the muscle give a better response.

7 Ordinarily treatment is given once a day six days a week. It is best to have each exercise done twice at first, gradually increasing the number until it can be done ten times without fatigue. The whole treatment including the massage takes from twenty minutes to an hour depending upon the extent of the paralysis It is preferable whenever possible to have two short exercise periods a day rather than one long treatment.

8 If the splint or apparatus is removed care should be taken not to allow the part to hang and no stretch or strain should be allowed on the muscles which are being kept shortened in the splint.

9 Always have the part which is being exercised uncovered

10 If possible be alone with the patient in order to secure his entire concentration.

The foundation of muscle training is an exact knowledge of muscle anatomy the origins insertions and actions. This is necessary in order to determine which muscles are weakened how they may be strengthened and which muscles may be trained to take the place of the weakened ones

The first preliminary to muscle training is an examination to determine the exact amount of power existing in the different muscle groups. For this it is necessary to have a knowledge of the easiest positions for obtaining response and action from very weak muscles.

Our standard classification for grades of power is

Gone—no contraction felt
Trace—muscle can be felt to tighten but can not produce movement.
Poor—produces movement with gravity eliminated but cannot function against gravity
Fair—can raise part against gravity
Good—can raise part against outside resistance as well as against gravity
Normal—can overcome a greater amount of resistance than a "good" muscle

The second preliminary to muscle training is an intelligent decision regarding which muscle groups are to be strengthened This is determined by

(a) The presence of deformity or permanent contracture of the muscles It is obviously unwise to strengthen muscles that are causing deformity or that are already contracted
(b) The likelihood of causing deformity In the presence of unequal balance of power about a joint, it is unwise to strengthen a muscle which already overbalances its opponent if this is likely to cause deformity
(c) The relative importance of weakened muscles in regard to useful function of the limb walking correction of a limp etc The danger of fatigue from too many exercises should be borne in mind.

The third preliminary to muscle training is a knowledge of the type of exercise best suited to the amount of power remaining in the muscle to be developed.
There are three general types of exercises

a. Those against gravity
b With gravity eliminated or neutralized
c. With help of gravity

There are three methods of giving an active or voluntary exercise

a. With assistance.
b Unaided or free.
c. Against resistance.

Type *a* exercises against gravity are suitable for fair and good muscles
Type *b* exercises with gravity eliminated or neutralized, are suitable for poor muscles and may be given in any one of the three ways named i.e with assistance unaided or against resistance according to the strength of the muscle

carries out the motion "with help" The patient should be instructed not to return the part to the starting position, but to relax after each effort and allow the operator to do the return movement passively

3 See that the full arc of the motion is obtained each time. If necessary help should be given in completing the arc, being careful to allow no pause at the point where the patient s strength gives out.

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a. With assistance
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c. Against resistance.

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Type *b* exercises with gravity eliminated or neutralized. are suitable for poor muscles and may be given in any one of the three ways named i.e with assistance unaided or against resistance according to the strength of the muscle

Type *c* exercises with the help of gravity must be given against sufficient resistance to equal or support the weight of the limb, otherwise the part either will drop without the desired muscle action, or will be lowered by the opposite group

In examining to establish a grade, it is first necessary to know whether the movement can be performed in a certain position, and next, whether the muscles can also overcome resistance while performing the movement. The determination of whether the strength is "good" or "normal" can best be told by having the patient hold the position while the examiner pulls until the muscles yield—the same principle used in the spring-balance muscle test as originally described by Lovett and Martin. Considerable experience with patients of different ages is necessary to make this differentiation between good and normal accurate but the presence of some normal muscles is often an assistance in making the decision

In giving exercises it is not advisable to make a practice of having the patients hold the positions until their strength is overcome as in examining for this is fatiguing It is better to have the muscles perform the movement against a graduated resistance, which should never be great enough to prevent the movement from being carried through smoothly

In the following description it is to be taken for granted that

(a) Help is given to finish the movement whenever the muscles are unable to do so
(b) The part is to be guided so that the movement is performed correctly
(c) The instructor replaces the part in the starting position after each effort
(d) Resistance is to be given whenever the muscles are strong enough to overcome it.

Since the positions used in examining muscles to determine their strength are often the same as the positions used for giving exercises to those muscles the description of both will be given under the heading of the movement performed The muscles which are in a position to help with the movement are listed under each heading.

Hip Extension —Gluteus maximus Gluteus medius and minimus. Hamstrings. Adductor magnus

EXAMINATION —

1 Prone lying.

FAIR muscles—should be able to raise the leg from the table with straight knee keeping the leg in line with the body GOOD or NORMAL muscles—should be able to do this against downward pressure given by the examiner and should hold the raised position against considerable pressure given on the thigh above the knee to lessen the participation of the hamstring muscles

2 Affected side lying with the knee drawn up to the chest. POOR muscles—should be able to perform at least part of the movement of pushing the thigh down and back into extension and may be able to complete the movement even against some resistance but cannot raise the leg against gravity in the prone position

EXERCISES —For GOOD or FAIR muscles.

1 Prone lying patient raises leg in air with straight knee.
2 Prone lying with the legs hanging over the edge of the table patient raises leg to horizontal (This position will lessen the amount of movement occurring in the lumbar spine)
For POOR muscles.
3 Affected side lying with the underneath knee drawn up to the chest, patient pushes the thigh down and back into extension
4 Patient lying on his back with the leg supported in the vertical position—pushes his leg down to the table against the resistance of the instructor's supporting hands. The knee should be kept straight throughout to eliminate effort at knee extension.
5 Opposite side lying with the affected leg supported in the instructor's hands—same exercise as in No 3

Hip Flexion *—Psoas major and iliacus Rectus femoris. Sartorius Adductors longus and brevis. Pectineus Gracilis Obturator externus

EXAMINATION —

1 Sitting erect on edge of table legs hanging
FAIR muscles—should raise the knee to the chest.
GOOD or NORMAL muscles—should do this against a good deal of downward pressure. A tendency for the thigh to flex or hold in outward rotation signifies greater strength in the sartorius than in the other muscles concerned
2 Affected side lying
POOR muscles—should be able to perform at least part of the movement of drawing the thigh up to the body

EXERCISES —For GOOD or FAIR muscles

1 Sitting erect on edge of table—patient raises the knee to the body without tipping the body back or rotating the thigh
2 Lying on the back—patient brings the knee up to the body
For POOR muscles
3 Affected side lying patient draws the knee of the underneath leg up to the body
4 Prone lying with legs off the end of the table—the leg is grasped at the ankle and raised to horizontal—patient then pulls the knee down and under the table gravity helping.

* Hip flexion exercises should not be given if any hip flexion contraction exists.

Type *c* exercises with the help of gravity, must be given against ufficient resistance to equal or support the weight of the limb other ise the part either will drop without the desired muscle action, or will lowered by the opposite group

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2 Affected side lying with the knee drawn up to the chest. POOR muscles—should be able to perform at least part of the movement of pushing the thigh down and back into extension and may be able to complete the movement even against some resistance but cannot raise the leg against gravity in the prone position.

EXERCISES —For GOOD or FAIR muscles

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For POOR muscles
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4 Patient lying on his back with the leg supported in the vertical position—pushes his leg down to the table against the resistance of the instructor's supporting hands The knee should be kept straight throughout to eliminate effort at knee extension
5 Opposite side lying with the affected leg supported in the instructor's hands—same exercise as in No 3

Hip Flexion.*—Psoas major and iliacus Rectus femoris, Sartorius Adductors longus and brevis Pectineus. Gracilis. Obturator externus.

EXAMINATION —

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GOOD or NORMAL muscles—should do this against a good deal of downward pressure A tendency for the thigh to flex or hold in outward rotation signifies greater strength in the sartorius than in the other muscles concerned.
2 Affected side lying.
POOR muscles—should be able to perform at least part of the movement of drawing the thigh up to the body

EXERCISES —For GOOD or FAIR muscles.

1 Sitting erect on edge of table—patient raises the knee to the body without tipping the body back or rotating the thigh.
2 Lying on the back—patient brings the knee up to the body
For POOR muscles.
3 Affected side lying patient draws the knee of the underneath leg up to the body
4. Prone lying with legs off the end of the table—the leg is grasped at the ankle and raised to horizontal—patient then pulls the knee down and under the table gravity helping

* Hip flexion exercises should not be given if any hip flexion contraction exists.

5 Opposite side lying with the affected leg supported in the instructor's hands—same exercise as in No 3

duction —Gluteus medius and minimus Gluteus maximus, upper fibers Sartorius and the small outward rotators of the hip, when the hip is flexed Tensor fasciae femoris.

EXAMINATION —

1 Lying on the opposite side.
FAIR abductors should raise the upper leg in the air through the normal range of abduction

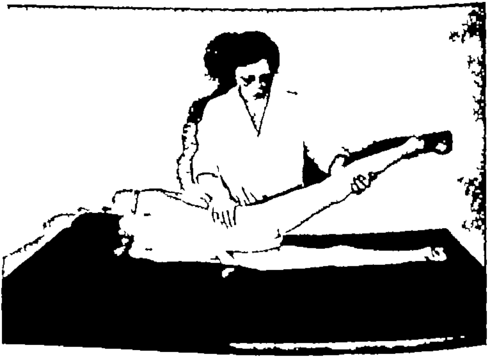

FIG 33 —Guiding hip bductio

GOOD muscles should do so against downward pressure.
The strength of the tensor fasciae femoris is obtained better if the leg is raised in some flexion while the action is more purely gluteal if the leg is kept in line with the body and the knee straight

It will be found that the tensor fasciae femoris can hold the leg with good power at about a horizontal level but is not able to fini h the full range of abduction without fair power in the gluteus medius and minimus.

2 Lying on the back with the pelvis held
POOR muscles should be able to move the leg out to the side.

EXERCISES —For GOOD or FAIR muscles.

1 Lying on the opposite side of the body, patient raises the upper leg in abduction.

For POOR muscles

2 Lying on the back pelvis held patient moves the leg out to the side without rotation of the leg or flexion of the knee Powder may be used to lessen friction or the leg may be supported in the instructor's hands

3 Prone lying—same exercise This position requires more effort from the gluteal muscles and less from the flexor abductors

4. Sitting—abduction of the thigh particularly suitable for the flexor abductors

Flexion abduction exercises should not be given if any contraction of the tensor fasciae femoris exists

TEST FOR CONTRACTURE OF TENSOR FASCIAE FEMORIS

Patient prone lying with legs hanging over the table edge Examiner holds pelvis down with one hand and with the other hand under the knee grasps leg and raises the thigh in line with the body until horizontal and then adducts it This position brings out a beginning contracture more clearly than when movement in the lumbar spine is allowed to take place

Adduction.—Adductor longus Adductor magnus Adductor brevis Gracilis Quadratus femoris Lower fibers of gluteus maximus Pectineus

EXAMINATION —

1 Lying on affected side with other leg held up by examiner in position of abduction

FAIR muscles should raise the under leg several inches from the table

2 Lying on the back with the leg out in abduction.

POOR muscles should draw the leg in toward the other leg

On account of frequent substitution of the internal hamstrings the thigh should not be allowed to rotate outward and the adductor tendon should be felt.

EXERCISES —For GOOD or FAIR muscles.

1 Lying on the affected side patient raises the affected leg from the table knee straight

For POOR muscles

2 Lying on the back with the leg out in abduction patient draws the leg in to the other leg keeping the foot pointing straight in the air

3 Lying on the opposite side with the affected leg supported in the air in abduction patient pulls the leg down gravity assisting

5 Opposite side lying with the affected leg supported in the instructor's hands—same exercise as in No 3

Abduction.—Gluteus medius and minimus Gluteus maximus, upper fibers Sartorius and the small outward rotators of the hip, when the hip is flexed. Tensor fasciae femoris

EXAMINATION —

1 Lying on the opposite side.
FAIR abductors should raise the upper leg in the air through the normal range of abduction

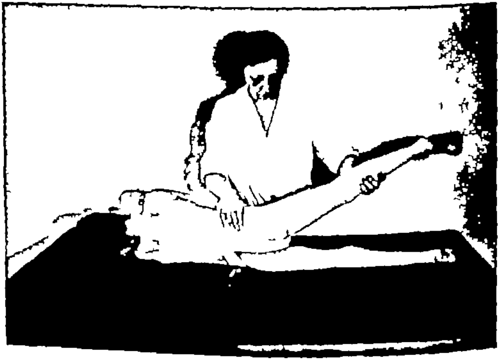

FIG 33 —Guiding hip abduction

GOOD muscles should do so against downward pressure.
The strength of the tensor fasciae femoris is obtained better if the leg is raised in some flexion while the action is more purely gluteal if the leg is kept in line with the body, and the knee straight.

It will be found that the tensor fasciae femoris can hold the leg with good power at about a horizontal level but is not able to finish the full range of abduction without fair power in the gluteus medius and minimus

2 Lying on the back with the pelvis held
POOR muscles should be able to move the leg out to the side.

4 Sitting on the edge of the table with the thigh in abduction, patient draws the thigh into the other leg

INTERNAL AND EXTERNAL ROTATION OF THE THIGH

There is considerable divergence of opinion among authorities as to the muscles taking part in these movements, and examination is generally unsatisfactory This is because the small muscles, such as the gemelli cannot be seen or felt to function, and the other muscles can be more accurately tested in their other functions Furthermore, it is not uncommon to find a patient walking with his leg in external rotation in spite of the fact that his strength in internal rotation is apparently greater when he is off his feet Since the small hip-outward rotators are generally supposed to abduct the thigh, when the hip is flexed and to rotate it out, when the thigh is extended, some idea of their strength can be obtained by trying outward rotation in both positions of the thigh.

External Rotation.—

Sartorius Pectineus	Posterior fibers of gluteus medius and minimus
Adductor longus Adductor brevis	Lower fibers of gluteus maximus
Adductor magnus Biceps	Iliopsoas
Pyriformis Gemelli Quadratus femoris Obturator externus and internus	when thigh is in extension

EXAMINATION AND EXERCISE.—

1 Sitting with lower legs hanging
FAIR muscles should raise the lower leg across in front of the other leg while rotating the thigh out.

2 Lying on the back.
POOR muscles should roll the whole leg outward.

Internal Rotation.—Tensor fasciae femoris Anterior fibers of gluteus medius and minimus.

EXAMINATION AND EXERCISE.—

1 Sitting with knees flexed lower legs hanging patient should raise lower leg to the side away from the other leg while keeping the knees together

2 Lying on the back, patient should roll the whole leg in from the hip.

EXTENSION

Knee —Quadriceps

EXAMINATION —

1 For normal strength in a child Squatting in deep knee-bend position with all the weight on one leg patient comes to the erect position by straightening the bent knee Patient s other leg and hands may be steadied by the examiner This test is not suitable for adults or markedly overweight children and gastrocnemius and gluteus maximus strength are also required in order to attain the erect position

2 Sitting on edge of table legs hanging
FAIR muscles should raise the lower leg to horizontal without thigh rotation.
GOOD muscles should do this against downward pressure. It is difficult to decide whether this muscle is normal because sufficient force may be exerted against older children to raise the patient s body from the table without causing the knee to bend and yet a history may be given of weakness shown in normal or athletic activities

3 Affected side lying with the thigh held firmly in slight extension by the examiner knee flexed,
POOR muscles should be able to perform at least part of the movement of straightening the knee and may be able to perform it against some resistance but cannot extend it in the sitting position against gravity

EXERCISES —For GOOD or FAIR muscles

1 Sitting on edge of table patient raises lower leg to horizontal.

2 Lying on back with lower leg hanging over edge of table patient raises lower leg to horizontal (The additional tension placed on the rectus femoris in this position makes the exercise slightly easier than in the sitting position)

3 Lying on back, raising the leg in the air with straight knee is more properly a hip flexion exercise.
For POOR muscles

4 Affected side lying same position as in examination No 3 The exercise is made easier by holding the thigh firmly back in extension, or somewhat harder if the thigh is held in some flexion during the movement of knee extension The greater tension of the rectus femoris in the first position makes it easier to start the movement than when the muscle is relaxed by hip flexion

5 Lying on the back "setting' the muscle by attempting to pull on the patella without moving the leg.

6 Prone lying with the knee flexed and lower leg vertical patient extends the knee against resistance given in front of the ankle

4 Sitting on the edge of the table with the thigh in abduction, patient draws the thigh into the other leg

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External Rotation.—

Sartorius	Posterior fibers of gluteus medius and minimus
Pectineus	
Adductor longus	Lower fibers of gluteus maximus
Adductor brevis	
Adductor magnus	Iliopsoas
Biceps	
Pyriformis	when thigh is in extension
Gemelli	when thigh is in extension
Quadratus femoris	when thigh is in extension
Obturator externus and internus	when thigh is in extension

EXAMINATION AND EXERCISE —

1 Sitting with lower legs hanging
FAIR muscles should raise the lower leg across in front of the other leg while rotating the thigh out
2 Lying on the back.
POOR muscles should roll the whole leg outward.

Internal Rotation.—Tensor fasciae femoris Anterior fibers of gluteus medius and minimus.

EXAMINATION AND EXERCISE.—

1 Sitting with knees flexed lower legs hanging patient should raise lower leg to the side away from the other leg while keeping the knees together
2 Lying on the back patient should roll the whole leg in from the hip

For POOR muscles

2 Affected side lying thigh of lower leg held firmly patient bends the knee If the thigh is held forward in flexion the exercise will be easier than if the thigh is held in line with the body

3 Lying on back with the leg held vertical by the instructor patient bends the knee pulling the lower leg down against the resistance of the instructor's supporting hand—thigh remains vertical

4. Sitting on the edge of the table with the lower leg supported at horizontal patient bends the knee pulling the leg down under the table.

Plantar Flexion (bending ankle so that toes point down) —Gastrocnemius and soleus Peroneus longus and brevis Flexor digitorum longus Plantaris Tibialis posticus Flexor hallucis longus

EXAMINATION —

1 Standing on one foot.
NORMAL muscles should raise the body weight on the tiptoes at least ten times
GOOD muscles should enable the patient to walk on tiptoes or rise on tiptoes less than ten times

2 Prone lying foot off the table edge
FAIR muscles should point the foot up against considerable downward pressure on the ball of the foot.

3 Affected side lying knee straight
POOR muscles should push the foot down It is important to watch for action of the tendo achillis since this is the tendon of the strongest plantar flexor the gastrocnemius Of the other plantar flexors the long toe flexors will act first on the toes before moving the ankle and the peroneals and posterior tibial act first on the forefoot. Gastrocnemius strength shown by the pull of the tendo achillis on the heel is necessary for good plantar flexion function.

EXERCISES.—For GOOD muscles

1 Standing on one foot rise on tiptoes or walk on tiptoes

For FAIR muscles

2 Lying face down with the knee flexed and the lower leg vertical or with the knee straight and the foot over the edge of the table patient plantar flexes ankle against pressure on the ball of the foot.

For POOR muscles

3 Patient sitting points the foot down against resistance

4 Affected side lying patient points the foot down being careful to use the tendo achillis

Thigh should be held down firmly by the instructor This exercise may be made harder for stronger muscles by increasing the resistance and by starting the movement with the knee completely flexed so that gravity must be overcome at first.

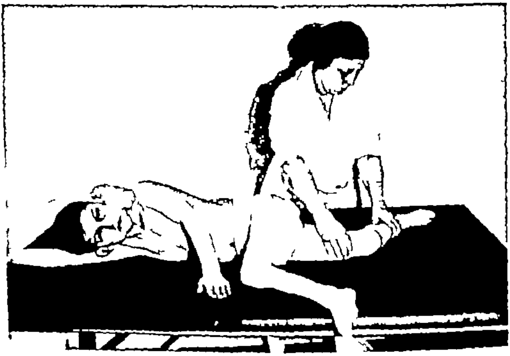

Fig. 34.—Exercise for "poor" knee extensor—thigh fixed.

FLEXION

Knee.—Biceps. Popliteus. Sartorius. Gracilis Semimembranosus. Semitendinosus. Gastrocnemius. Plantaris

Examination —

1 Prone lying
FAIR muscles should raise the lower leg to vertical
GOOD or NORMAL muscles should do this against downward pressure on the lower leg. The thigh should be held down firmly throughout movement
2 POOR muscles affected side lying with the thigh held firmly in front of the body hip flexed to give greater tension on the ham string muscles. Examiner should feel the tendons of both the internal and external hamstring muscles during flexion of the knee.

Exercises —For GOOD or FAIR muscles
1 Prone lying patient bends the knee raising the lower leg to vertical.

For POOR muscles

3 Lying on the back patient turns the foot in.

4 Prone lying with the foot off the end of the table patient turns the foot in

Deformity which results from weakness of this group—valgus (foot is displaced outward)

Exercise to be avoided—eversion

EVERSION

Peroneus longus, brevis tertius   Extensor digitorum longus

EXAMINATION AND EXERCISES —

1 Sitting or lying patient turns the foot out

The strength of the movement and the amount of resistance over come determine the grading

Deformity which results from weakness of this group—varus (foot is turned in)

Exercise to be avoided—inversion

Since these muscles take part in more than one movement of the foot or toes and it is not uncommon for one muscle to be weaker than the others of its group, it is customary to estimate their strength separately as well as testing the group as a whole

The tibialis anterior is a dorsal flexor of the foot as well as an invertor Its tendon is the innermost of the three tendons which can be seen and felt across the front of the ankle joint in a normal foot. In carrying out the examination positions and exer cises just described the larger part of the movement will be performed by the tibialis anterior if the foot is pulled up at the same time that it is being turned in

The tendon of the tibialis posterior can be felt just above and behind the internal malleolus and it can be felt to contract more strongly if the foot is pointed down as it is being turned in

The extensor digitorum longus extends the four lesser toes but its strength is best obtained while carrying out the movement of dorsiflexion with the foot in slight abduction

The extensor hallucis longus extends the great toe, but its strength is best obtained in dorsiflexion Its tendon may sometimes be confused with that of the tibialis anterior unless it is traced to its insertion on the toe

The great toe and the next three toes can sometimes be ex tended in the absence of the long toe extensors by the extensor digitorum brevis Inability to identify motion of the tendons of the long extensors where they cross the ankle joint accompanied by loss of dorsiflexion power will justify the examiner in attribut ing extension power in these four toes to the extensor digitorum brevis or to the interossei

Deformity which results from weakness of this group—calcaneus —the weight coming heavily on the heel in walking
Exercise to be avoided—dorsiflexion

Dorsiflexion (bending the ankle up) —Tibialis anterior Extensor hallucis longus Extensor digitorum longus Peroneus tertius.

EXAMINATION —

1 Sitting with lower leg hanging over the edge of the table.
FAIR muscles should bend the ankle up to a right angle, if not prevented by a short heel cord.
GOOD muscles should do this against downward pressure on the top of the foot. (Even strength in the four muscles will result in the foot being brought up straight, but in case of unequal power one side of the foot may be raised higher than the other or held more firmly in that position when resistance is given)
2 Lying on the affected side
POOR muscles should bend the ankle up

EXERCISES —For FAIR and GOOD muscles
1 Sitting on the edge of the table patient bends the ankle up in dorsiflexion. Instructor should guide the foot straight, if it tends to turn out or in during the movement.
For POOR muscles
2 Affected side lying patient bends the ankle up in dorsiflexion.
3 Back lying the same exercise
4 Prone lying with the lower leg held vertical and the foot pointed in the air patient bends the ankle in dorsiflexion, pulling the toes down toward the table
Deformity resulting from weakness of this group—foot drop
Exercise to be avoided—plantar flexion

INVERSION

Tibialis anterior	Tibialis posterior
Extensor hallucis longus	Flexor hallucis longus

EXAMINATION —For FAIR and GOOD muscles
(The lower leg should be held to prevent rotation)
1 Lying on affected side patient lifts the forefoot from the table while keeping the heel on the table.
For POOR muscles
2 Sitting on the edge of the table patient turns the foot in.

EXERCISES —For FAIR or GOOD muscles
1 Lying on affected side patient lifts the forefoot from the table.
2 Sitting on the edge of the table, patient turns the foot in against resistance

For POOR muscles

3 Lying on the back patient turns the foot in

4 Prone lying with the foot off the end of the table patient turns the foot in

Deformity which results from weakness of this group—valgus (foot is displaced outward)

Exercise to be avoided—eversion

EVERSION

Peroneus longus, brevis tertius Extensor digitorum longus

EXAMINATION AND EXERCISES.—

1 Sitting or lying patient turns the foot out

The strength of the movement and the amount of resistance over come determine the grading

Deformity which results from weakness of this group—varus (foot is turned in)

Exercise to be avoided—inversion

Since these muscles take part in more than one movement of the foot or toes, and it is not uncommon for one muscle to be weaker than the others of its group it is customary to estimate their strength separately as well as testing the group as a whole.

The tibialis anterior is a dorsal flexor of the foot as well as an invertor Its tendon is the innermost of the three tendons which can be seen and felt across the front of the ankle joint in a normal foot. In carrying out the examination positions and exer cises just described the larger part of the movement will be performed by the tibialis anterior if the foot is pulled up at the same time that it is being turned in

The tendon of the tibialis posterior can be felt just above and behind the internal malleolus, and it can be felt to contract more strongly if the foot is pointed down as it is being turned in

The extensor digitorum longus extends the four lesser toes but its strength is best obtained while carrying out the movement of dorsiflexion with the foot in slight abduction.

The extensor hallucis longus extends the great toe but its strength is best obtained in dorsiflexion Its tendon may sometimes be confused with that of the tibialis anterior unless it is traced to its insertion on the toe.

The great toe and the next three toes can sometimes be ex tended in the absence of the long toe extensors by the extensor digitorum brevis. Inability to identify motion of the tendons of the long extensors where they cross the ankle joint accompanied by loss of dorsiflexion power will justify the examiner in attribut ing extension power in these four toes to the extensor digitorum brevis or to the interossei.

Deformity which results from weakness of this group—calcaneus —the weight coming heavily on the heel in walking.
Exercise to be avoided—dorsiflexion

Dorsiflexion (bending the ankle up) —Tibialis anterior Extensor hallucis longus. Extensor digitorum longus. Peroneus tertius.

Examination —

1 Sitting with lower leg hanging over the edge of the table
Fair muscles should bend the ankle up to a right angle, if not prevented by a short heel cord
Good muscles should do this against downward pressure on the top of the foot. (Even strength in the four muscles will result in the foot being brought up straight, but in case of unequal power one side of the foot may be raised higher than the other or held more firmly in that position when resistance is given.)

2 Lying on the affected side.
Poor muscles should bend the ankle up

Exercises —For fair and good muscles

1 Sitting on the edge of the table patient bends the ankle up in dorsiflexion Instructor should guide the foot straight if it tends to turn out or in during the movement.
For poor muscles.

2 Affected side lying patient bends the ankle up in dorsiflexion.

3 Back lying the same exercise

4 Prone lying with the lower leg held vertical and the foot pointed in the air patient bends the ankle in dorsiflexion, pulling the toes down toward the table.
Deformity resulting from weakness of this group—foot drop
Exercise to be avoided—plantar flexion

INVERSION

Tibialis anterior	Tibialis posterior
Extensor hallucis longus	Flexor hallucis longus

Examination —For fair and good muscles
(The lower leg should be held to prevent rotation)

1 Lying on affected side patient lifts the forefoot from the table while keeping the heel on the table.
For poor muscles

2 Sitting on the edge of the table patient turns the foot in

Exercises —For fair or good muscles

1 Lying on affected side patient lifts the forefoot from the table

2 Sitting on the edge of the table patient turns the foot in against resistance

2 Side lying position with hips passively flexed attempt to bend head down to knees Assistance may be given to lessen friction of table by placing the examiner's hand under the patient s shoulder
3 Back lying abdominal retraction Flattening should not be obtained by elevation of the chest.

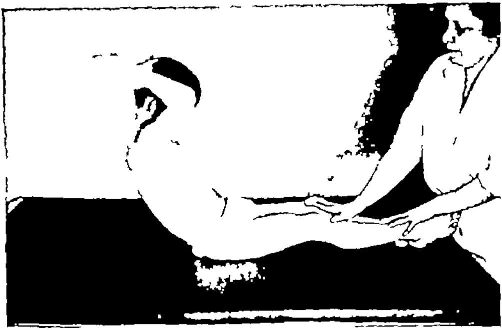

FIG. 35 —Test for "normal" anterior abdominal muscles.

4 Back lying forcible exhalation of a deep breath as in attempting to blow up a balloon
5 Using hip flexors back lying flex hips and draw knees up to chest, attempting to raise hips from table

Lateral Flexion.—Obliquus externus and internus. Quadratus lumborum. Rectus abdominis Erector spinae. Latissimus dorsi of side to which lateral movement takes place

EXAMINATION —

1 Lying on the opposite side with legs and pelvis held down firmly by the examiner the patient raises head and shoulders from the table A fixed scoliosis will make this test of little value.
2 Back lying trunk flexion to side pelvis held fixed
3 Back or prone lying patient attempts to draw hip toward ribs of the same side without flexing hip or knee It is sometimes possible to distinguish the difference in strength between the quadratus lumborum and the lateral abdominal muscles in this test.

EXERCISES —Same as above

FLEXION

Toes.—Flexor hallucis longus—distal phalanx of the great toe. Flexor digitorum longus—distal phalanges of four lesser toes. Flexor hallucis brevis—first phalanx of great toe. Abductor and adductor hallucis—first phalanx of great toe Lumbricales and interossei—first phalanges of four lesser toes Flexor digitorum brevis—middle phalanges of four lesser toes.

EXAMINATION AND EXERCISE —

1 Sitting or lying, patient curls the toes under bending all three joints to insure action of all the muscles mentioned. The amount of strength can be judged by placing a finger across under the toes and offering resistance at the different joints It is not uncommon to find that the middle and terminal joints can be flexed by the long flexors without any bending of the first joints or the first joints may bend without any curling of the ends

Trunk.—Rectus abdominis. Quadratus lumborum Obliquus externus and internus

EXAMINATION —

1 Lying on back, feet held down, patient raises head and shoulders, flexing spine in coming to a sitting position This should be possible for a normal child with the hands on top of his head, but may not be possible for an adult of poor general muscular tone unless assistance is given In a child the anterior abdominal muscles may be rated FAIR if shoulders can be raised from table GOOD if he can come to sitting position with arms folded on chest. Good anterior neck muscles are required to raise the head in this test and their severe weakness allowing the head to hang a dead weight, sometimes makes it difficult to judge the strength of fairly good abdominal muscles The last part of the movement of coming to an erect sitting position is accomplished by flexion of the pelvis on the thighs by the hip flexors Strong hip flexor action with weak abdominal muscles will result in flexing the pelvis and arching the lumbar spine without trunk raising, or in accomplishing the sitting position with the lumbar spine first fixed in hyperextension by the erector spinae muscles.
2 Lying on back pulling in the abdominal muscles while examiner feels their firmness

EXERCISES —

1 Same as first examination May be given with assistance with hands at hips folded on chest at neck or on top of head to increase the difficulty May be started from half lying position to make easier If undesirable to exercise hip flexors, should raise the head and thorax only

humerus starting from the hanging position is advanced forward flexed to the horizontal line and thence it is elevated to the vertical position on the return journey the humerus is depressed through 180 degrees to the hanging position and then it can be carried backward "hyperextended." In the *lateral plane* the *hanging humerus can be* abducted to the horizontal line and thence elevated to the vertical position and on the *return journey it is adducted through 180* degrees to the hanging position In the horizontal plane the humerus is horizontally adducted when it is moved from the lateral plane toward the middle line and horizontally abducted when away from the middle line to the lateral plane behind which it is horizontally retracted. Besides these movements there is rotation in and out.

In "flexing" the humerus, the anterior fibers of the deltoid, the clavicular fibers of the pectoralis major the biceps, and probably the coracobrachialis contract and carry the humerus forward nearly to the horizontal line. This action of the deltoid tends to rotate the scapula with the acromion downward and to push its inferior angle backward and toward the spinal column but this is prevented by the contraction of the acromion (middle) fibers of the trapezius and also the lower fibers. The deltoid and other muscles cannot carry the humerus further than the horizontal line Beyond this point the serratus magnus comes to their assistance and draws the lower end of the scapula forward raises the acromion with the humerus and thus the arm is elevated to the vertical.

In a case with paralyzed lower and middle trapezius and normal serratus *on telling the patient to advance the arm slowly the* first action on the scapula was to rotate it so that the inferior angle moved half an inch toward the vertebral column and the posterior border of the scapula projected like a wing this projection reached its maximum when the humerus was advanced through about 45 degrees Then the serratus contracted and as it drew the lower end of the scapula forward the deformity diminished and finally disappeared Though the serratus is mechanically in the position to fix the scapula and prevent its lower angle being pushed backward and rotated toward the spine it is not its function when the movement is one of advancing the shoulder to act on the scapula until the humerus has been moved by the deltoid through about 45 degrees The inferior part of the trapezius apparently is the proper muscle to fix the scapula in advancing the humerus and when these inferior fibers are paralyzed the serratus will not step into the breach and do the work for the trapezius which consequently is not done at all

The above description of advancing the humerus applies equally well to movement of abduction of the humerus except that the middle part of the deltoid and the supraspinatus abduct the humerus, and the pectoralis major does not act but the same condition is met with in regard to movements of the scapula and its relation to the trapezius and serratus as in flexing the humerus.

EXTENSION

Erector spinae group

EXAMINATION —Prone lying trunk raising Accompanied by tightening of hip extensors and trapezius, head raising and scapulae adduction.

EXERCISES —

1 Prone lying legs held down trunk raising May be done with hands clasped behind back, at hips, at shoulders, or behind neck, to increase difficulty
2 Side lying starting from curled up position, straightening of head and trunk.
3 Sitting with trunk bent forward, patient comes to erect position.
4 Sitting in erect position patient lowers trunk forward from hips without bending spine, and then returns to erect position

Neck.—Sternocleidomastoids

EXAMINATION —

1 Back lying shoulders held down head raising from table. These muscles acting together should be able to hold the head in the raised position against considerable pressure, if normal.
2 To test them separately lying on back, patient turns face to right side against resistance at point of chin as test for left muscle

EXERCISES —

1 and 2 Same as above.
3 Lying on back patient bends head toward shoulder of side it is desired to exercise
4. Lying on side patient bends head forward

As it is not possible to observe or feel the action of the deeper neck muscles no attempt is made to describe their action. In general whatever function is weak should be given as an exercise.

The platysma is frequently seen standing out in a broad sheet when the attempt is made to raise the head with weak sternocleidomastoid muscles The cervical spine and the head are fixed by the extensor muscles and the attempt is made to raise the head by raising the trunk with the abdominal muscles in many cases of weakness of the anterior neck muscles.

SHOULDER MOVEMENTS *

The movements of the humerus are best described in terms of the planes corresponding to the three dimensions of space, viz antero-posterior laterovertical horizontal In the anteroposterior plane, the

* Extracts from Croonian Lectures on Muscular Movements and Their Representation in the Central Nervous System, by Charles Beevor

Extension of Humerus (bringing arm down from flexion) —Pectoralis major (sternal part) Latissimus Teres major and minor Infraspinatus Triceps long head Subscapularis (probably)

Hyperextension (carrying arm back of body) —Latissimus Teres major and minor Infraspinatus Deltoid (posterior part)

Scapula fixed as in adduction

Horizontal Adduction of Humerus (starting from position of abduction bringing arm forward at shoulder level) —Pectoralis major (both parts) Anterior deltoid Coracobrachialis

Horizontal Abduction of Humerus (carrying arm back at shoulder level) —Posterior and middle deltoid Latissimus Teres major and minor Infraspinatus

Scapula adducted and fixed by trapezius (middle)

External Rotation of Humerus.—Teres mino Infraspinatus Posterior part of deltoid

Internal Rotation.—Pectoralis major Teres major Latissimus Subscapularis Anterior portion of deltoid

Elevation of Shoulder (shrugging) —Upper part of trapezius Rhomboids Levator anguli scapulae

Depression of Shoulder —Lower part of trapezius Pectoralis minor Latissimus dorsi Subclavius

Since each shoulder muscle takes part in several movements it is necessary to know which of these movements is performed mainly by the muscle we desire to test, and often it is necessary to know the strength of the assisting muscles before forming our opinion by a process of elimination Some of the shoulder and arm muscles have to be graded by observation of the strength of the action rather than by gravity tests

Trapezius.—May be considered in four parts

$\left.\begin{array}{l}\text{1 Clavicular}\\ \text{2 Acromial}\end{array}\right\}$ upper

3 Middle—horizontal fibers

4 Lower

It is very difficult to separate the action of the upper two portions unless there is marked difference in strength. In most cases the acromial and clavicular portions may be considered together as the "upper

Clavicular—extension of head rotation of head to opposite side flexion of head to same side elevation of shoulder

In paralysis of the trapezius the inferior angle of the scapula in the first part of the movement of abduction moves more toward the spine and does not project so much backward as in flexing the humerus. Normally in advancing the arm the scapula hardly moves at all until the humerus makes an angle of about 45 degrees and then the inferior angle begins to move outward by the commencing action of the serratus and when the humerus is horizontal the angle with the scapula remains constant and the elevation of the humerus to vertical is completed by the serratus. If however, the deltoid be paralyzed or the shoulder be ankylosed, the serratus begins to act at once and the scapula moves outward at once

The projection or winging of the scapula may be caused by paralysis of the trapezius and especially of its lower fibers, as well as by paralysis of the serratus The difference is that the deformity due to absence of the trapezius is less than that of the serratus the scapula projecting only one half to one inch, that the projection reaches its maximum when the humerus is advanced through about 45 degrees after which the deformity diminishes and disappears when the humerus is horizontal and that the humerus can be raised to vertical With serratus paralysis the deformity increases as the arm is advanced and reaches its maximum when the humerus is horizontal above which there is no muscular power to raise it In serratus paralysis the scapula can be displaced backward by pushing against the advanced arm.

Flexion (raising arm forward) —Anterior deltoid. Coracobrachialis. Biceps Clavicular part of pectoralis major

1 During the first part of flexion, the lower middle and acromial portions of the trapezius contract to fix the scapula and prevent its being displaced backward when the humerus approaches to the horizontal line the serratus magnus rotates the scapula upward and the humerus is carried on up to vertical by this rotation.
2 Abduction of humerus to horizontal in laterovertical plane. Started by supraspinatus at 10 or 15 degrees the anterior and middle parts of the deltoid begin to act aided by the long head of the biceps

Abduction above horizontal line muscle action is the same as in flexion above horizontal.

Adduction (of humerus to side) —Pectoralis major sternal and clavicular parts Latissimus dorsi Teres major and minor Infraspinatus. Posterior part of deltoid Subscapularis (probably)

The scapula is fixed during movement of the arm by rhomboids, pectoralis minor and lower part of trapezius

Extension of Humerus (bringing arm down from flexion) —Pectoralis major (sternal part) Latissimus Teres major and minor Infraspinatus Triceps long head Subscapularis (probably)

Hyperextension (carrying arm back of body) —Latissimus Teres major and minor Infraspinatus Deltoid (posterior part)

Scapula fixed as in adduction

Horizontal Adduction of Humerus (starting from position of abduction bringing arm forward at shoulder level) —Pectoralis major (both parts) Anterior deltoid Coracobrachialis

Horizontal Abduction of Humerus (carrying arm back at shoulder level) —Posterior and middle deltoid Latissimus Teres major and minor Infraspinatus

Scapula adducted and fixed by trapezius (middle)

External Rotation of Humerus.—Teres mino Infraspinatus Posterior part of deltoid

Internal Rotation.—Pectoralis major Teres major Latissimus Subscapularis Anterior portion of deltoid

Elevation of Shoulder (shrugging) —Upper part of trapezius Rhomboids Levator anguli scapulae

Depression of Shoulder —Lower part of trapezius Pectoralis minor Latissimus dorsi. Subclavius

Since each shoulder muscle takes part in several movements it is necessary to know which of these movements is performed mainly by the muscle we desire to test, and often it is necessary to know the strength of the assisting muscles before forming our opinion by a process of elimination Some of the shoulder and arm muscles have to be graded by observation of the strength of the action rather than by gravity tests

Trapezius.—May be considered in four parts

1 Clavicular } upper
2 Acromial }
3 Middle—horizontal fibers
4 Lower

It is very difficult to separate the action of the upper two portions unless there is marked difference in strength. In most cases the acromial and clavicular portions may be considered together as the "upper

Clavicular—extension of head rotation of head to opposite side flexion of head to same side elevation of shoulder

Acromial —rotates acromion process upward, elevates scapula.
Middle —fixes and adducts scapula in horizontal abduction of humerus.
Lower —(a) fixes scapula during flexion or abduction of humerus, paralysis is shown by displacement of inferior angle of scapula toward vertebrae at the start of these movements also by winging of vertebral border of scapula, (b) fixes scapula during adduction or depression of humerus, acting with rhomboids and pectoralis minor

To determine trapezius strength test head extension, elevation of shoulder scapulae adduction watch position of inferior angle of scapula during abduction of humerus, and watch for contraction of the middle and lower fibers during the exercise of trunk raising from the prone position

Serratus Magnus.—(a) Draws the scapula forward around the chest (b) Rotates the scapula upward, bringing the lower angle outward

EXAMINATION —

1 Patient sitting with the arm in abduction at shoulder level GOOD muscle should rotate the scapula so that the arm is raised to vertical (The weight of the arm may be supported by the examiner if the deltoid is not strong enough to hold it.)
2 Sitting with the arm at shoulder level the patient should reach forward. The examiner should steady the patient's body with one hand grasp the outstretched arm above the elbow with the other hand and by pushing the humerus try to displace the scapula backward. If the serratus magnus is weak, the scapula will be displaced so that its vertebral border approaches the spine

EXERCISES.—

1 Sitting or lying movement of the arm from shoulder level to vertical
2 Sitting or lying abduction or flexion of the arm from the side to vertical will bring in the action of the serratus and trapezius, if the scapula is not fixed
3 Lying face down with the arm hanging over the edge of the table. (a) Patient may reach down to try to touch the floor, (b) patient may swing the arm to try to catch the end of the table above his head.

Movement.—Abduction of arm

MUSCLE.—Deltoid anterior portion.

EXAMINATION —

1 Patient sitting with the scapula held down firmly by the examiner to exclude its rotation with the resultant raising of the humerus FAIR muscles should raise the arm to shoulder level at the side To exclude the biceps as much as possible from assisting in the movement, the arm should be raised with the elbow passively flexed forearm hanging or with the elbow straight, and the palm down.
GOOD muscles should raise the arm to the side against downward pressure given above the elbow
2 Patient lying on his back, with the scapula held down by the examiner
POOR muscles should perform all or part of the movement of abduction from the side to shoulder level.

EXERCISES —For FAIR or GOOD muscles
1 Sitting with the scapula held down, patient raises arm from the side to shoulder height.
2 Lying on the opposite side patient raises the upper arm to shoulder level Scapula should be kept from rotating
For POOR muscle.
3 Lying on the back, scapula held, patient moves the arm from the side to shoulder level
4 Lying on the back free movement of the arm from the side to shoulder level and above to the ear

In any movement of abduction of the arm during which the scapula is not prevented from rotating the action will not be localized in the deltoid Instead the movement will be a combined exercise in which the upward rotators of the scapula also take part and do most of the work if they are stronger than the deltoid.

MUSCLE.—Deltoid posterior portion Horizontal abduction

EXAMINATION —

1 Patient lies face down with the arm stretched out in abduction at the shoulder level
FAIR muscle should raise the arm from the table.
GOOD muscle should raise the arm against resistance
Normally the scapula is adducted toward the spine at the same time by the middle portion of the trapezius and the rhomboids If the arm is raised by the posterior deltoid without this adduction of the scapula these muscles are weak. On the other hand the scapula adduction may take place when the posterior deltoid is too weak to lift the arm
2 POOR muscle should be seen to act when the patient abducts his arm from his side to the level of the shoulders In this position the posterior deltoid works to overcome the friction of the table

Acromial —rotates acromion process upward elevates scapula.
Middle —fixes and adducts scapula in horizontal abduction of humerus.
Lower —(a) fixes scapula during flexion or abduction of humerus paralysis is shown by displacement of inferior angle of scapula toward vertebrae at the start of these movements also by winging of vertebral border of scapula (b) fixes scapula during adduction or depression of humerus, acting with rhomboids and pectoralis minor

To determine trapezius strength test head extension elevation of shoulder, scapulae adduction watch position of inferior angle of scapula during abduction of humerus, and watch for contraction of the middle and lower fibers during the exercise of trunk raising from the prone position

Serratus Magnus.—(a) Draws the scapula forward around the chest. (b) Rotates the scapula upward bringing the lower angle outward.

EXAMINATION —

1 Patient sitting with the arm in abduction at shoulder level. Good muscle should rotate the scapula so that the arm is raised to vertical (The weight of the arm may be supported by the examiner if the deltoid is not strong enough to hold it.)
2 Sitting with the arm at shoulder level the patient should reach forward. The examiner should steady the patient s body with one hand grasp the outstretched arm above the elbow with the other hand and by pushing the humerus try to displace the scapula backward If the serratus magnus is weak the scapula will be displaced so that its vertebral border approaches the spine.

EXERCISES —

1 Sitting or lying movement of the arm from shoulder level to vertical
2 Sitting or lying abduction or flexion of the arm from the side to vertical will bring in the action of the serratus and trapezius if the scapula is not fixed
3 Lying face down with the arm hanging over the edge of the table. (a) Patient may reach down to try to touch the floor, (b) patient may swing the arm to try to catch the end of the table above his head.

Movement —Abduction of arm.

MUSCLE.—Deltoid anterior portion

although the middle portion of the muscle has more to do with abducting the arm.

EXERCISES —

1 FAIR or GOOD muscle should perform the same movement used in examination position No 1
2 POOR muscle should perform the movement used in examination position No 2
3 POOR muscle, sitting with the arm stretched out in front of his face resting on a table at the height of his shoulders patient moves the arm back until it is in line with his shoulders at the side—horizontal abduction

MUSCLE.—Latissimus dorsi hyperextension with internal rotation

EXAMINATION —

1 Lying face down.
FAIR muscle should raise the arm from the table keeping it close to the side and inwardly rotated
GOOD muscle should perform the above movement against resist ance
2 POOR muscle should adduct the arm to the side from a starting position of abduction at shoulder level

EXERCISES —

1 For FAIR and GOOD muscles 2 For POOR muscles	The same movement as described in the examination

MUSCLE —Pectoralis major

EXAMINATION —

1 Patient lies on his back, arm out at shoulder level
FAIR muscle should raise the arm to vertical above the face in movement of horizontal adduction Both sternal and clavicular portions act in this
GOOD muscle should perform the above movement against resist ance
2 POOR muscle brings arm to side from shoulder level—adduction movement.
3 Lying or sitting if the other muscles are strong enough to raise the arm forward in flexion the clavicular part of the pectoralis major may be made to stand out by resisting the movement of flexion and the sternal part by resisting the movement of exten sion.

EXERCISES —

1 For FAIR or GOOD muscle use movement described in examination.
2 For POOR muscle use movement described in examination.

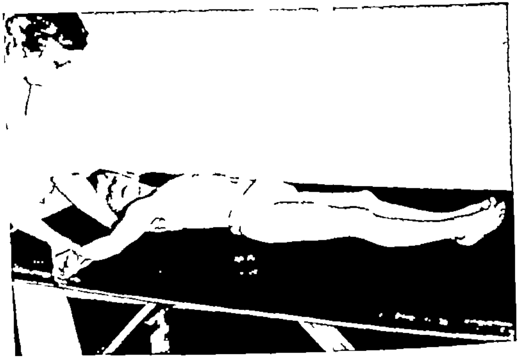

Fig. 36—Finish of exercise for "poor" deltoid muscle (anterior half) Notice that the scapula is being held.

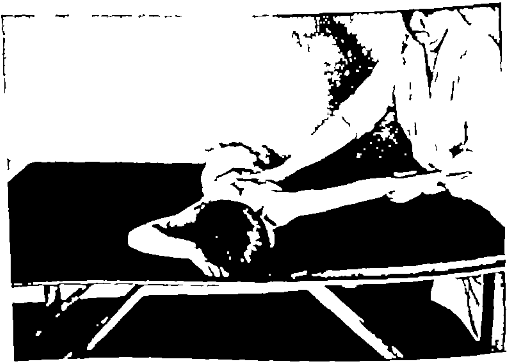

Fig 37 — Fair" posterior deltoid.

although the middle portion of the muscle has more to do with abducting the arm

EXERCISES —

1 FAIR or GOOD muscle should perform the same movement used in examination position No 1
2 POOR muscle should perform the movement used in examination position No 2
3 POOR muscle sitting with the arm stretched out in front of his face resting on a table at the height of his shoulders patient moves the arm back until it is in line with his shoulders at the side—horizontal abduction

MUSCLE.—Latissimus dorsi hyperextension with internal rotation

EXAMINATION —

1 Lying face down
FAIR muscle should raise the arm from the table keeping it close to the side and inwardly rotated.
GOOD muscle should perform the above movement against resistance
2 POOR muscle should adduct the arm to the side from a starting position of abduction at shoulder level

EXERCISES —

1 For FAIR and GOOD muscles 2 For POOR muscles	The same movement as described in the examination.

MUSCLE.—Pectoralis major

EXAMINATION —

1 Patient lies on his back, arm out at shoulder level
FAIR muscle should raise the arm to vertical above the face in movement of horizontal adduction Both sternal and clavicular portions act in this
GOOD muscle should perform the above movement against resistance
2 POOR muscle brings arm to side from shoulder level—adduction movement
3 Lying or sitting if the other muscles are strong enough to raise the arm forward in flexion the clavicular part of the pectoralis major may be made to stand out by resisting the movement of flexion and the sternal part by resisting the movement of extension

EXERCISES —

1 For FAIR or GOOD muscle use movement described in examination.
2 For POOR muscle use movement described in examination

3 For POOR muscle, sitting with his arm resting on a table at shoulder height, out in position of abduction patient brings the arm forward in horizontal adduction.

Movement.—Outward rotation

MUSCLES —Teres minor Infraspinatus Deltoid, posterior part.

EXAMINATION —

1 Lying face down, with the upper arm out at shoulder level and the forearm hanging over the edge of the table, with the elbow bent at a right angle
FAIR muscles should rotate the upper arm outward thus raising the hand and forearm above the level of the table
GOOD muscles can hold the arm in this position against downward pressure on the forearm
2 Lying on the back with arm at the side
POOR muscles should turn the arm outward at the shoulder, rolling the elbow back. The elbow must be watched to make sure that the upper arm turns as well as the hand and forearm.

EXERCISES —For FAIR or GOOD muscles
1 Use position described in examination of these muscles.
2 Sitting with the upper arm and forearm supported at shoulder level elbow flexed to a right angle, arm in abduction, patient raises forearm, thus performing outward rotation at the shoulder
For POOR muscles.
3 Use position and movement described in examination of poor muscles.
4. Lying face down with the whole arm hanging over the edge of the table elbow straight, patient turns the whole arm outward

ARM AND HAND MOVEMENTS

Movement.—Elbow flexion.

MUSCLES —Biceps. Brachialis. Brachioradialis. Pronator teres. Flexors of the wrist. Flexor digitorum sublimis.

EXAMINATION —

1 Patient sits with the arm hanging at the side
FAIR muscles should raise the forearm so that the hand touches the shoulder
GOOD muscles raise the forearm against resistance.
2 Patient sits with the whole arm supported on a table elbow straight hand resting on the fifth finger
POOR muscles bend the elbow without raising the forearm from the table

The biceps is the strongest flexor and acts with the palm turned toward the patient s face—that is with the forearm in supination. Inability to flex the elbow with the forearm in this position indicates weakness of the biceps and exercises should be directed toward its development since the other elbow flexors cannot make up for its loss

EXERCISES —For FAIR and GOOD muscles

1 Patient sitting with his arm hanging touches his fingers to his shoulder

For POOR muscles

2 Sitting with the entire arm supported on the table at shoulder height elbow straight hand resting on the fifth finger patient bends the elbow drawing the forearm along the table.

3 Lying on the back with the entire arm supported vertically in the air patient bends the elbow pulling the hand down toward the face with the aid of gravity against the resistance of the examiner's supporting hand The upper arm must be held vertical by mother throughout.

Movement. —Elbow extension

MUSCLES —Triceps Anconeus

EXAMINATION —

1 Lying on the back or sitting erect with the upper arm held vertical the elbow flexed and the forearm hanging

FAIR muscles should straighten the elbow raising the forearm to vertical.

GOOD muscles should raise the forearm in this position against some downward pressure from the examiner

2 Lying on the back or sitting with the entire arm resting flat on the table elbow bent.

POOR muscles should perform at least part of the movement of straightening the elbow

EXERCISES —For FAIR and GOOD muscles

1 Patient straightens his elbow in the same position used for grad ing these muscles.

For POOR muscles

2 With the arm and forearm resting on a table patient attempts to straighten the bent elbow

3 Sitting hand touching shoulder patient pushes his forearm down ward against sufficient resistance to neutralize the weight of the arm

3 For POOR muscle, sitting with his arm resting on a table at shoulder height, out in position of abduction, patient brings the arm forward in horizontal adduction

Movement.—Outward rotation

MUSCLES —Teres minor Infraspinatus Deltoid posterior part.

EXAMINATION —

1 Lying face down with the upper arm out at shoulder level and the forearm hanging over the edge of the table, with the elbow bent at a right angle.
FAIR muscles should rotate the upper arm outward thus raising the hand and forearm above the level of the table.
GOOD muscles can hold the arm in this position against downward pressure on the forearm.
2 Lying on the back with arm at the side.
POOR muscles should turn the arm outward at the shoulder, rolling the elbow back. The elbow must be watched to make sure that the upper arm turns as well as the hand and forearm.

EXERCISES —For FAIR or GOOD muscles
1 Use position described in examination of these muscles
2 Sitting with the upper arm and forearm supported at shoulder level elbow flexed to a right angle arm in abduction patient raises forearm, thus performing outward rotation at the shoulder
For POOR muscles.
3 Use position and movement described in examination of poor muscles
4 Lying face down with the whole arm hanging over the edge of the table, elbow straight patient turns the whole arm outward.

ARM AND HAND MOVEMENTS

Movement.—Elbow flexion

MUSCLES —Biceps Brachialis Brachioradialis. Pronator teres. Flexors of the wrist. Flexor digitorum sublimis.

EXAMINATION —

1 Patient sits with the arm hanging at the side
FAIR muscles should raise the forearm so that the hand touches the shoulder
GOOD muscles raise the forearm against resistance.
2 Patient sits with the whole arm supported on a table, elbow straight hand resting on the fifth finger
POOR muscles bend the elbow without raising the forearm from the table

EXAMINATION —

1 Patient sitting with the palm of the hand resting on the table FAIR extensors should raise the hand from the table GOOD muscles would overcome resistance as well. The fingers should not be held in extension unless it is desired to have the finger extensors assist in the movement.

2 With the ulnar side of the forearm and hand resting on the table POOR extensors should bend the wrist back in extension

EXERCISES —These are given in the same positions as in the examination

Movement.—Wrist abduction

MUSCLES —Flexor and extensor carpi radialis Extensors of the thumb

EXAMINATION AND EXERCISE —Hand resting on the table palm up Patient bends the wrist toward the thumb side without moving forearm

Movement.—Wrist adduction.

MUSCLES —Flexor and extensor carpi ulnaris

EXAMINATION AND EXERCISE —Patient bends the wrist toward the ulnar side without moving forearm. These lateral movements are used chiefly when inequality exists between the radial and ulnar muscles

Movement.—Finger extension.

MUSCLES —Extensor digitorum communis extends the proximal phalanges

EXAMINATION AND EXERCISE.—Patient pushes back the proximal phalanges of the four fingers either alone or against resistance keeping middle and end joints flexed loosely

Movement.—Finger extension

MUSCLES —Interossei and lumbricales extend the second and third phalanges

EXAMINATION —Patient extends the middle and end joints of the fingers either alone or against resistance The first phalanges should be held by the examiner in extension during the movement. If the first phalanges are held passively flexed the extensor digitorum communis can extend the second and third phalanges without the interossei and lumbricales

Movement.—Supination of forearm

MUSCLES —Biceps Supinator brevis Brachioradialis.

EXAMINATION AND EXERCISE.—Sitting with the elbow flexed to a right angle, palm turned down, patient turns the forearm, palm up
Resistance to the movement may be given by grasping the forearm just above the wrist.

Movement.—Pronation of forearm.

MUSCLES —Pronator radii teres Pronator quadratus Flexor carpi radialis

EXAMINATION AND EXERCISE —Sitting with the elbow flexed to a right angle palm up patient turns the forearm palm down Resistance as for supination

Movement.—Wrist flexion

MUSCLES —Flexor carpi radialis Palmaris longus Flexor carpi ulnaris Long flexors of the fingers and thumb

EXAMINATION —

1 Patient sitting with the back of the hand resting on the table. FAIR flexors should bend the wrist, palm up, raising the hand against gravity
Good muscles would overcome resistance as well.
The fingers should be relaxed to localize the action in the other muscles.
2 Sitting with the ulnar side of the forearm and hand resting on the table midway between pronation and supination
POOR flexors should bend the wrist gravity being eliminated
It will be necessary for the examiner to feel the different tendons to know what part each muscle is taking in the movement.

EXERCISES —For GOOD FAIR or POOR flexors
1 and 2 These are given in the same positions as the test Nos. 1 and 2
3 For POOR muscles with the forearm resting on the table in pronation hand extending over the table edge patient bends the wrist downward against enough resistance to neutralize the weight of the hand

Movement.—Wrist extension

MUSCLES —Extensor carpi radialis longus and brevis. Extensor carpi ulnaris. Long extensors of fingers and thumb

EXAMINATION —

1 Patient sitting with the palm of the hand resting on the table. FAIR extensors should raise the hand from the table. GOOD muscles would overcome resistance as well. The fingers should not be held in extension unless it is desired to have the finger extensors assist in the movement.

2 With the ulnar side of the forearm and hand resting on the table POOR extensors should bend the wrist back in extension

EXERCISES —These are given in the same positions as in the examination

Movement.—Wrist abduction.

MUSCLES —Flexor and extensor carpi radialis Extensors of the thumb

EXAMINATION AND EXERCISE —Hand resting on the table palm up Patient bends the wrist toward the thumb side without moving forearm

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MUSCLES —Extensor digitorum communis extends the proximal phalanges

EXAMINATION AND EXERCISE.—Patient pushes back the proximal phalanges of the four fingers either alone or against resistance keeping middle and end joints flexed loosely

Movement.—Finger extension.

MUSCLES —Interossei and lumbricales extend the second and third phalanges

EXAMINATION —Patient extends the middle and end joints of the fingers either alone or against resistance The first phalanges should be held by the examiner in extension during the movement. If the first phalanges are held passively flexed the extensor digitorum communis can extend the second and third phalanges without the interossei and lumbricales

Movement.—Supination of forearm.

MUSCLES —Biceps Supinator brevis Brachioradialis.

EXAMINATION AND EXERCISE —Sitting with the elbow flexed to a right angle, palm turned down, patient turns the forearm, palm up
Resistance to the movement may be given by grasping the forearm just above the wrist.

Movement.—Pronation of forearm

MUSCLES —Pronator radii teres Pronator quadratus Flexor carpi radialis

EXAMINATION AND EXERCISE —Sitting with the elbow flexed to a right angle palm up patient turns the forearm, palm down. Resistance as for supination

Movement.—Wrist flexion

MUSCLES —Flexor carpi radialis Palmaris longus. Flexor carpi ulnaris Long flexors of the fingers and thumb

EXAMINATION —

1 Patient sitting with the back of the hand resting on the table. FAIR flexors should bend the wrist palm up, raising the hand against gravity
Good muscles would overcome resistance as well
The fingers should be relaxed to localize the action in the other muscles
2 Sitting with the ulnar side of the forearm and hand resting on the table midway between pronation and supination
POOR flexors should bend the wrist gravity being eliminated
It will be necessary for the examiner to feel the different tendons to know what part each muscle is taking in the movement.

EXERCISES —For GOOD FAIR or POOR flexors
1 and 2 These are given in the same positions as the test Nos. 1 and 2
3 For POOR muscles, with the forearm resting on the table in pronation hand extending over the table edge patient bends the wrist downward against enough resistance to neutralize the weight of the hand

Movement.—Wrist extension

MUSCLES —Extensor carpi radialis longus and brevis. Extensor carpi ulnaris Long extensors of fingers and thumb

EXAMINATION —

1 Patient sitting with the palm of the hand resting on the table. FAIR extensors should raise the hand from the table. GOOD muscles would overcome resistance as well The fingers should not be held in extension unless it is desired to have the finger extensors assist in the movement.

2 With the ulnar side of the forearm and hand resting on the table POOR extensors should bend the wrist back in extension

EXERCISES —These are given in the same positions as in the examination

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Movement.—Wrist adduction

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Extensor indicis proprius and extensor digiti quinti proprius assist the extensor communis to extend their respective fingers, but either may act in the absence of the common extensor

Movement.—Finger flexion

MUSCLES —Those of *first* phalanges mainly interossei and lumbricales

EXAMINATION —Patient should be tested with fingers outstretched. Movement is aided by flexor digitorum sublimis and flexor digitorum profundus if fingers are allowed to flex.
Those of *second* phalanges, flexor digitorum sublimis and flexor digitorum profundus
Those of *third* phalanges flexor digitorum profundus.

Movement.—Adduction of fingers, to middle finger

MUSCLES —Palmar interossei

1st	palmar interosseus	adducts	index finger
2nd	" "	"	fourth "
3rd	" "	"	fifth "

EXAMINATION AND EXERCISE —Be careful to avoid flexing at same time.

Movement.—Abduction of fingers—from an imaginary line drawn through the middle finger

MUSCLES —Dorsal interossei Abductor digiti minimi

1st	dorsal interosseus	abducts	index finger
2nd	" "	moves	middle finger toward index finger
3rd	" "	"	" " " fourth "
4th	" "	"	fourth " " fifth "

Abductor digiti minimi abducts fifth finger

EXAMINATION AND EXERCISE.—Have patient spread all fingers apart or each separately and hold the position Fingers should be kept flat during movement.

Movement.—Thumb extension

MUSCLES —Extensor pollicis longus—first the terminal joint, then the proximal joint, and the carpometacarpal Extensor pollicis brevis—proximal joint and carpometacarpal Extensor ossis metacarpi pollicis (abductor longus)—carpometacarpal joint.

Movement.—Thumb flexion

MUSCLES —Flexor pollicis longus—all three joints especially the terminal one Flexor pollicis brevis—metacarpal bone and first

phalanx. Opponens pollicis—metacarpal bone. Abductor pollicis brevis—metacarpal bone Adductor pollicis—metacarpal bone

EXAMINATION —Patient flexes thumb across the palm, keeping thumb flat to palm

Movement.—Thumb opposition.

MUSCLES —Opponens pollicis Flexor pollicis brevis. Abductor pollicis brevis Adductor pollicis

EXAMINATION —

Patient abducts thumb at right angles to palm and then approximates it to fingers and ulnar side of hand keeping a space open between the thumb and the palm

Atrophy of both the abductor brevis and opponens pollicis produces a general flattening of the thenar eminence. Atrophy mainly of the opponens pollicis is shown by a hollow along the metacarpal bone on the radial side of the thenar eminence

FACIAL PARALYSIS AND THROAT

The following movements should be tried and practiced as exercises, before a mirror if needed The two sides of the face should be carefully compared In the case of unilateral weakness there will be more movement on the stronger side This will be especially noticeable in laughing

FIG. 38.—Case showing permanent facial and nasal deviation 15 years after onset

Fig. 39.—Right facial involvement.

and crying as the mouth cheek and nostril are drawn to that side producing a grotesque expression which the patient may erroneously attribute to trouble with the stronger side

1 Raise the eyebrows wrinkling the forehead
2 Scowl drawing the eyebrows together
3 Close the eyes
4 Open the eyes wide.
5 Turn the eyeballs from side to side
6 Wrinkle the nose and sniff
7 Smile notice the corners of the mouth as well as the cheek.
8 Pucker the lips to whistle
9 Open the mouth dropping the jaw evenly
10 Close the mouth with pressure as in chewing
11 Move the lower jaw from one side to the other
12 Run the tongue out straight.
13 With the mouth open notice whether the arch of the soft palate is the same on both sides and whether it is lifted equally when the patient says a ah. In addition to sagging on the paralyzed side the uvula may be drawn to the stronger side

Any difficulty with speech swallowing raising mucus coughing or sneezing should be noted

Respiration

It is difficult to grade the strength of the muscles of respiration but varying degrees of paralysis which may be unilateral or bilateral are often detected in the after-care of patients who have had acute respiratory involvement in the early stages of the disease Careful observation of the movements of the abdomen and of the chest wall is essential in order to determine whether the breathing is being carried on mostly by the diaphragm or by the intercostal muscles and whether it is alike on both sides A fluoroscopic examination will sometimes be of assistance in showing the amount of excursion of the diaphragm on the two sides.

A normal child lying quietly moves the chest very little in ordinary breathing With each inspiration there is a slight bulging of the abdomen from the increased pressure caused by the descent of the diaphragm When asked to take a deep breath the chest is raised but normal children often fail to show more than one-half inch chest expansion unless they have been trained to do breathing exercises. For this reason too much significance should not be attached to small chest expansion in a poliomyelitis patient, unless there is a history of respiratory involvement or unless there are obvious signs of unusual activity of the accessory muscles in the effort to lift the chest.

Diaphragm.—

1 Observation of an unusual amount of chest expansion on each inspiration accompanied by a sucking in of the upper abdomen, indicates severe weakness of the diaphragm

2 The examiner may hold the patient's ribs firmly to interfere with the action of the intercostal muscles in attempting to raise the chest, while he observes the abdomen. A strong action of the diaphragm on inhalation will produce a perceptible bulge in the abdominal wall, and respiration will go on without discomfort, in spite of the restricted chest movement.

Intercostals.—

1 In severe paralysis of these muscles with a good diaphragm, the abdomen bulges markedly on each inspiration, and the chest flattens particularly in the region of the lower ribs which are sucked in by the pull of the diaphragm

2 The examiner holds the lower ribs and the abdomen firmly against motion and the patient is urged to expand the chest with a deep breath The scaleni and the sternocleidomastoids normally act to raise the chest in forced inspiration, as do the serrati, pectorals, etc. but their action is much more marked when the intercostals are involved

Exercises.—

1 The patient should be taught to breathe with whichever muscles do not produce normal excursion on inspiration.
Pressure on the ribs by the examiner's hands will help to localize the action by preventing movement at that point and forcing expansion elsewhere

2 Arm raising and rib-stretching exercises should be included to prevent contractures which may hold the ribs in a sunken position.

3 Forcible expiration will also be useful.

Equipment for Muscle Training

The only equipment necessary is a table which can be made by any carpenter It should be large enough to support a patient lying on his back with both legs in full abduction. For many patients especially children a somewhat narrower table will be satisfactory if the worker steadies the patient s foot or hand when it is extended over the edge. The exact measurements will differ according to whether or not adults as well as children must be planned for but it should be possible for the average patient to lie on his side with his hips flexed and the underneath leg extended at a right angle to his body We have tables five feet five and one-half and six feet in length varying in width from three to four feet. It is better not to have them hinged for adjustable back supports as any cracks or hinges increase friction or pro-

vide an obstacle which has to be avoided For the same reason drop leaves on a narrower table which is ordinarily used for other purposes are not as satisfactory as a solid top A table of the required size may be built with folding legs and stood against the wall when not in use if the floor space is needed for other purposes

While a wooden surface may be used patients will be more comfortable if a few layers of harness felt are laid on the wood extending over its edges and this is covered by a smooth leatherette or a waterproof covering which comes for automobile tops.

When it is necessary to give exercises in a bed it is desirable to have as firm a mattress as possible both to lessen friction and insure more accurate movements than can be obtained in a soft bed which sags in the middle Often a board placed under the mattress or a linoleum covered board, like a table top placed under the patient, will make a satisfactory substitute for a table

It should be emphasized again that it is not the equipment but the choice of suitable exercises and the technic of giving them that constitutes efficient treatment of paralyzed muscles The kitchen table and even the kitchen floor have been utilized many times in homes where no other facilities were available

Various aids may be devised to assist very weak muscles in producing movements or to reduce friction Dusting powder may be used or slings to support the weight of the limb in exercises such as abduction with or without the use of pulleys or pendulum weights A support with a ball bearing joint is sometimes used for the limb Such devices may serve to stimulate the interest of the patient, but in most cases the hands of the worker can give more accurate localization of the movement while at the same time giving the necessary support and assistance

The action of any mechanical exercises should be very carefully analyzed before consent is given for their use by patients whose muscles are severely paralyzed or whose muscle balance has been affected The general criticisms of their use are

1 Evidences of beginning fatigue cannot be recognized as readily as when the control of a movement is supplied either by the hands of an experienced worker or by a parent who has been accustomed to the reactions of that particular child.

2 Springs or weights may replace the active effort of the particular muscles most in need of exercise while the stronger antagonists are still further developed

3 Other muscles may be substituted and the movement performed in a faulty manner

The danger of overfatigue and the danger of neglect of scientific treatment on account of the use of some highly advertised mechanical appliance are the most serious arguments against their use

Therapeutic Exercise Pool

The practice of giving muscle training in an exercise pool will be found beneficial to many patients Its use seems particularly adapted to those whose muscles are so badly affected that they are able to produce little or no motion of the limbs on a table

It is customary to say that a muscle examination made in warm water will show a rating one grade higher than can be demonstrated outside. This is because the weight of the limbs is largely supported by the water and the pull of gravity is either greatly diminished or entirely overcome, so that the part floats In consequence less strength is required to move the part, and an easier set of exercises can be evolved which are better graduated for very weak muscles, because they provide the right amount of work without the insensible fatigue of overexertion. Undoubtedly the patient's enjoyment of the exercise period stimulates him to greater effort and so hastens his progress.

The same care must be given to the choice of exercises suitable to the degree of weakness of the muscles, and to the relative strength of the opposing group as has been previously described Equal attention must also be paid to localizing the movements in the desired muscles. The danger of the stronger muscles' neglect of the weaker ones, in general and recreative movements in the water is just as great as on land The instructor of normal children in the swimming pool is no more qualified to undertake the treatment of infantile paralysis patients in the water than the physical education instructor is qualified to treat them in the gymnasium It is far better to teach the mother just what exercises should be done either on a table or in the water, than to refer the child to the general swimming pool as a substitute for treatment. The general swimming pool may be of some benefit to the chronic case as a healthful recreation in which he can participate with others but it does not constitute efficient treatment and may do definite harm in increasing deformities

A therapeutic exercise pool of any size has the same problems as any other pool with regard to sterilization of water overflow drains cleanliness etc. Salt water may be used for additional buoyancy but is not necessary

The pool at the Children's Hospital Boston has a recirculation system of continuous flow liquid chlorine and triple gravel filters. The laboratory bacteriologic reports are almost sterile and at an average of 0 3 part per million of residual chlorine, there are very few complaints of irritation to the mucous membranes or eyes.

The water must be kept at a temperature of 90 to 94° F (32.22 to 34.44 C) or severely paralyzed patients will complain of cold While this temperature is uncomfortably warm for normal persons, it should be borne in mind that it is somewhat below body temperature, thus causing a loss of body heat. The cold limbs and poor circulation of paralyzed patients do not have the quick reaction and extra production

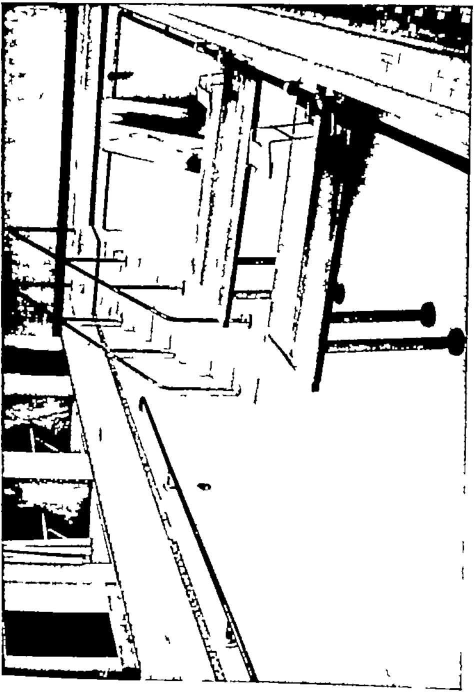

Fig. 40—Pool for muscle training—empty

Therapeutic Exercise Pool

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It is customary to say that a muscle examination made in warm water will show a rating one grade higher than can be demonstrated outside This is because the weight of the limbs is largely supported by the water, and the pull of gravity is either greatly diminished or entirely overcome, so that the part floats. In consequence, less strength is required to move the part and an easier set of exercises can be evolved which are better graduated for very weak muscles, because they provide the right amount of work without the insensible fatigue of overexertion Undoubtedly, the patient's enjoyment of the exercise period stimulates him to greater effort and so hastens his progress.

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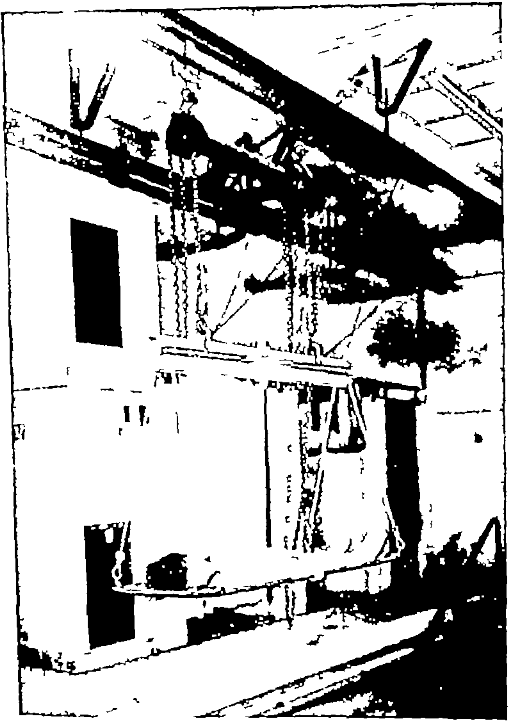

FIG. 4 —Frame carrier and hoist for transportation of severely involved cases from truck t pool

Fig. 4 —Pool for muscle training—filled.

see which ones are best suited to the functional ability of the muscles Some poor muscles will function best in a movement parallel to the surface of the water, while others accomplish more either in lifting the part toward the surface or in the opposite position of submerging it. The tension of the antagonistic muscles and the ability of the part to float are conditions which affect the difficulty of the exercise

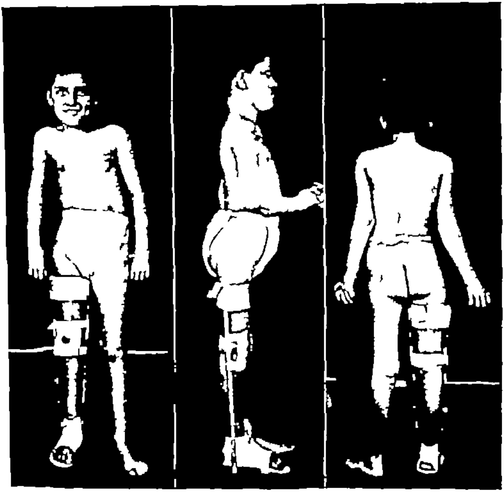

FIG. 44.—Galvanized-iron extension splints applied.

The trunk muscles respond especially well to exercises in water, and a greater variety can be worked out for weak abdominal and back muscles than can be performed on a table

The balance of the head and trunk in the erect sitting position may be gained by practicing in water which reaches above the shoulders The patient who has to learn to walk over again using braces and crutches makes much faster progress if he has had a preliminary training in the pool. Leg splints and a corset may be worn in the

of heat with which the normal person responds to a lower temperature, and chilling results with consequent loss of muscle effectiveness.

The routine precautions observed to prevent a spread of infection include nose and throat culture Wassermann test if the history suggests its need warm soap scrub on a table under a shower, and careful inspection for signs of a skin infection, a rash or a cold. Ambulatory patients wear paper slippers over bare feet outside the pool.

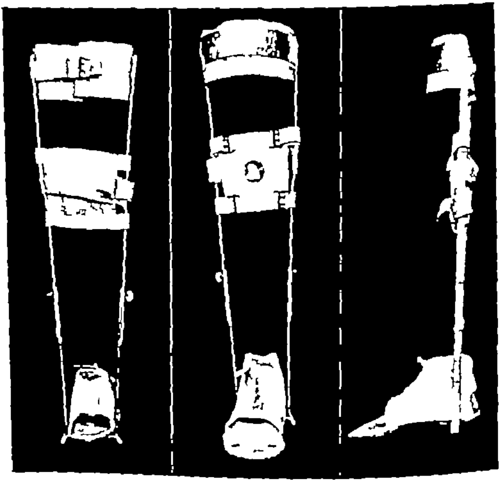

FIG 43—Galvanized-iron extension splints for walking in the pool.

A 15 or 20-minute rest should be required after the exercise period. A table submerged in the pool about 10 inches below the surface will be found of assistance in giving many exercises The legs may be fastened in sockets on the bottom of the pool if it is desired to have the table removable or one end may be hung from the hand rail with weighted legs at the other end to hold it down An inclined plinth under water will also be found useful

Many of the same exercise positions may be used in the water but it will be found necessary to try out the different positions to

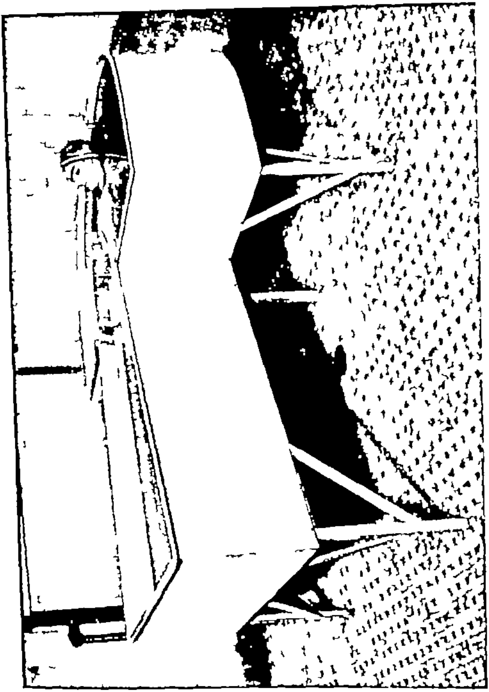

FIG. 46.—Hubbard tub for treating individual cases.

pool to prevent faulty weight bearing The problem of maintaining the balance, while shifting the weight from side to side as the legs are moved is made much easier when the body is supported by water of shoulder depth

Other problems of daily life, such as going up and down stairs and sitting down and getting up out of a chair may be mastered

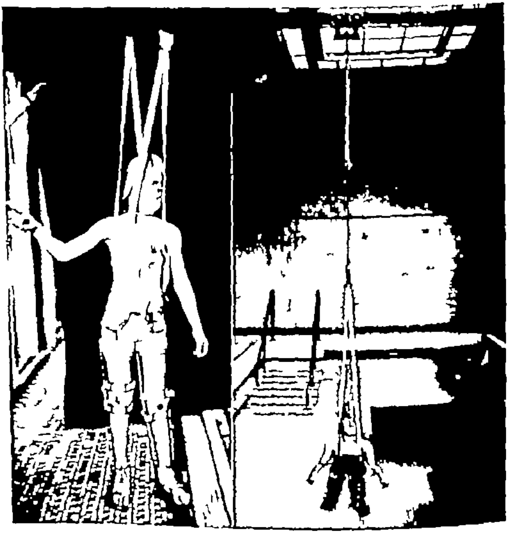

FIG 45 —Galvanized iron splints, corset and sling for walking in the pool.

more easily in the water Low stairs with hand rails extending out some distance under water will be found very useful in helping to make these patients independent

The use of an exercise tub is of very definite advantage to recently paralyzed patients Movements can be made without pain in the warm water even before the sensitiveness has gone and an immediate decrease in sensitiveness is usually noticed when physical therapy treat

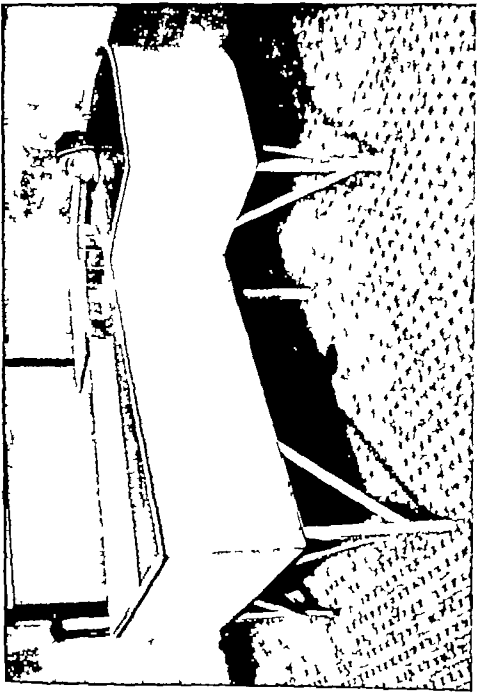

Fig. 46.—Hubbard tub for treating individual cases.

ment is started in this way Instead of using the large pool we prefer to submerge such patients on a Bradford frame in a table tub about 18 inches deep (large enough for one patient) About 100° F (37 78 C.) is the usual temperature while sensitiveness remains No attempt is made to force painful movements or to carry through a list of exercises The patient is allowed to move as he likes, and confidence is gained in the shallow water If there are beginning contractures, the patient is encouraged to try to overcome them, but no painful stretching is done The patient remains in the water about ten minutes and is then lifted on the frame and dried off with as little movement of sensitive joints as possible

Physical Therapy in Postoperative Conditions

Muscle training after tendon transplantations is of the greatest importance as the after treatment may mean the success or failure of the result

After a tendon transplantation the part must be immobilized in the corrected or overcorrected position. There is danger that atrophy and weakening of the muscle will take place if complete immobilization is continued for any considerable length of time. It is essential, however that time enough should be allowed for the transplanted tendon to become firmly attached to its new insertion, before allowing any motion

A tendon should be firmly enough attached after twelve or fourteen days to allow some pull to be made upon it It is my rule to begin baking and superficial massage without motion when the stitches are taken out usually after eight or ten days At this time the patient should also begin to set the muscle making one or two attempts to contract it After twelve to fourteen days the number of times the muscle is contracted may be gradually increased depending upon its response so that after two weeks regular muscle training is being carried on

In cases where a tendon has been transplanted to such a place that its new function will be entirely different from the original one, it is often necessary at the start to tell the patient to carry out the former function in order to have him perform the new one Patients will gradually learn with practice to perform the new function and as soon as this is accomplished the original function should be dropped from the list of exercises If there are other muscles of sufficient strength to initiate the movement or to assist the transplanted muscle in its new position it will regain good functional use more quickly

Great care should always be taken to prevent muscle fatigue from the treatment just as in the muscle training of cases where there has been no operation A weaker response should be the signal for rest rather than for repeated efforts to demonstrate the ability to function.

The first postoperative treatments should be given with the part

resting in half of the bivalved plaster Baking superficial massage and reeducation of the transplant can be given in this way before it is safe to have the part unsupported The region of the incision may be left covered by a small dressing if it is not entirely healed while treatment is given to the rest of the muscle

Tendons of partially paralyzed muscles must be carefully protected from stretching and they require a longer period of rest after their attachment in a new position than is necessary after the suture of a divided tendon whose insertion has not been disturbed

A bone operation such as a stabilization must be treated as a fracture whether or not a muscle transplantation has been done at the same time. Baking and massage may be started in two weeks provided that care is taken to prevent any motion at the joints operated upon and muscle training for a transplantation may be added in about four weeks

It is important to carry on massage and muscle training to keep up the circulation and tone of the affected muscles in other parts of the body during a period of postoperative inactivity Light work of this kind can usually be started soon after the disappearance of the early postoperative reaction and discomfort provided that care is taken to avoid any exercise or position which may cause strain on the immobilized part.

When weight bearing has been resumed much can be done in many cases to improve the patient s gait by special training to overcome faulty habits and to insure the use of a transplanted muscle in walking Instruction is often needed to aid the patient in acquiring good balance of the body after stabilization operations on the feet.

Much time can be saved and better results obtained if an intelligent use is made of physical therapy measures following operative procedures in the treatment of poliomyelitis

Necessity of Follow up

The importance of follow-up treatment in the after-care of poliomyelitis is very great

Since the maximum recovery from the effects of an attack of poliomyelitis can not be obtained in a few weeks or months if there has been any considerable degree of paralysis but is a long and tedious process in which the outcome is dependent upon the regular and faithful coöperation of the patient and his family some thought must be given to the problem of obtaining and keeping this coöperation

The parents of children affected with poliomyelitis should be given an honest, heart to-heart talk about what they have to expect and should have it explained to them that no one can tell how much recovery can be made by the weakened muscles but that whether or not their child regains the maximum amount possible to him depends to a large extent upon their faithfulness in carrying out treatment.

They should understand that there will be periods when no appreciable gain will be made but that neglect of treatment may allow the development of serious deformities and that muscles often start in to gain again after a stationary period

They should also realize that there are charlatans who will promise perfect cures and that, on the other hand there are reputable doctors who do not yet realize the improvement that can be gained by carefully planned muscle training and will tell them that it is not worth while to do anything more than wear braces. It is easy to understand the discouragement and the perplexity that the parents of paralyzed children must often feel and they should be given every legitimate encouragement to carry on for the good of the child

Daily treatment by an expert in muscle training with the frequent supervision of the surgeon, is of course the ideal method of treatment. Obviously this is possible for only a limited number and cannot be arranged for any large group of patients with restricted financial means who are scattered over a wide area.

Careful instruction of the mother so that she may carry on the proper exercises correctly in between the days when she reports to the clinic is the only practical method of follow up

It is our policy in the Harvard Infantile Paralysis Commission Clinic to have cases report three times a week to the clinic at the start of their treatment, so that the progress of each muscle may be watched carefully and the parent instructed in the exercises she should carry out at home on the other days

It is true that some parents are incapable of understanding and carrying out instructions in muscle training but a fairly intelligent mother will soon learn to carry out exercises if she realizes their value after being shown and made to perform them herself a few times under the direction of a capable worker These home exercises are of vital importance, for a patient will certainly lose muscle power if the treatment is not carried out daily For this reason it is necessary for a clinical physical therapy worker to have the ability to instruct the parents and obtain their coöperation As the parents learn to carry on correctly without supervision the patients visits to the clinic are gradually decreased to once a week and later to the intervals when it is desirable to have their progress inspected by the surgeon.

It is impossible for many parents to bring the patients to the clinic three times a week In these cases they must do the best they can with less frequent instruction and report as often as possible In order to insure that the treatment of such cases is carried on and not neglected any organization doing follow-up work must provide field workers to reach the patients at regular intervals. This may be done to some extent by visits to the homes or by the institution of so-called treatment clinics which are held by the workers at convenient local centers at weekly or other intervals. At these treatment clinics the worker carries out the same treatment which would have been given at the

hospital clinic and supervises the mother s methods of giving the exercises. She also notices whether the surgeon s instructions are being carried out and later reports to him any change in the patient s condition which requires his attention

These treatment clinics held near the homes are often more effective in encouraging the parents to continued effort than home visits since they have the opportunity to see the progress that other children are making and to hear how other mothers manage to meet the problems of getting in the daily exercise period and of making the children carry out the doctor s other instructions

After muscle training has gone on for a few weeks some muscles will be seen to have regained power faster than others For this reason it may be advisable to lessen the amount of exercise given these muscles and put more stress on the ones that are not regaining power so fast, in order to prevent any increase in imbalance

At regular intervals all patients should have a routine check-up by the surgeon which should include the following points

1 A complete reëxamination of muscle power which is made at intervals of once a month for the first three or four months and then every two months during the rest of the first year An examination every four months is often enough for the older cases.

This examination will determine the choice of muscles to be strengthened by the physical therapy worker until the next examination and will also control the decision of whether braces may be gradually discarded or should still be continued

2 An inspection of the braces at least every three or four months to insure that the chronic cases who require them permanently have the necessary alterations and repairs to match their growth.

3 From these routine examinations it can be determined whether the progress of the case is satisfactory in regard to muscle recovery or whether a stationary period has been reached If the latter there should be a consideration of whether some operative procedure may now be of service, without further delay

What Can Be Expected from Physical Therapy

It has been stated earlier that the greatest amount of spontaneous recovery of muscle power occurs during the second stage of poliomyelitis. This is the recovery following the absorption of the edema which had made pressure on some of the nerve centers of the spinal cord and temporarily interfered with their function but had not destroyed them.

The greatest gain due to muscle training is made in the first nine months to a year of treatment When the nerve centers controlling muscles are partially impaired weakness or partial paralysis of those muscles is present. Such muscles will gradually gain in power by frequent repetition of active contraction of their muscle fibers, but

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will only make their maximum recovery when protected from such unfavorable conditions as fatigue, over use, stretching etc. On the other hand, if these muscles are not caused to contract by exercise, they will weaken from disuse, atrophy and gradually degenerate.

After the first year, weakened muscles will continue to gain under treatment, but their progress will be much slower than that of the uninvolved muscles which will gain at the normal rate. For this reason too, after-care should be carried on for many years after the onset, in order to guard against an increasing imbalance which may bring about late deformities However the actual gain made by the weakened muscles after the first year is of sufficient importance to warrant keeping up muscle training

Just how much power can be regained, eventually, depends upon the amount of permanent injury which has been done to the nerve centers If all the nerve centers controlling a muscle have been destroyed there can be no return of power under any treatment, but the examiner is not justified in assuming this to be the case, on the strength of not obtaining any remnant of muscular contraction in the early examinations. A survey of 293 muscles which were rated totally gone on the initial examinations disclosed that two-thirds of these muscles showed some return of power after two years of treatment. When we group with the totally paralyzed muscles the next grade consisting of muscles which sometimes show a remnant of response but are unable to produce any movement of the part to which they are attached we find that 25 per cent, or one fourth of a total of 694 muscles unable to produce any movement on the first examination, are able to function against gravity after two years of treatment.

Muscles which are able to produce some movement at the time of the initial examination of course show a greater proportion of gain. Of 6127 muscles able to produce some movement, 89 per cent were able to function against gravity two years later

At the end of two years treatment, a survey showed that 62 per cent of all the muscles in any degree affected had become normal.

Only 13 per cent of the muscles which were classified as "good" had not recovered to normal 91 per cent of the 'fair' muscles had reached good or normal 58 per cent of the "poor" muscles had reached good or normal and 21 per cent more had become "fair," that is they were able to overcome gravity

These statements give an idea of the actual gain in muscle strength which can be expected from treatment, but they do not show the additional value to the individual patients, of the training which teaches them to utilize their assets In other words, physical therapy also includes the reëducation which teaches them how to walk again how to rise from chairs and handle themselves independently on stairs, as well as how to perform many of the other acts of normal life which represent the difference between an independent, though handicapped individual and a helpless cripple

CHAPTER NINE

PHYSICAL THERAPY IN CEREBRAL SPASTIC PARALYSIS

EDWIN W RYERSON M.D

Cerebral spastic paralysis for the purposes of this paper will be considered under three headings (1) The Congenital Form in Children. (2) The Acquired Form in Children (3) The Acquired Form in Adults

THE CONGENITAL FORM IN CHILDREN

The congenital form is usually due to injury during the process of parturition the skull being compressed during its passage through the birth canal, with a resulting intracranial hemorrhage from torn blood vessels The extent of the hemorrhage and its location will determine whether the infant dies immediately or lives with a greater or lesser degree of damage to the cranial contents

Routine lumbar punctures in more than nine hundred new born babies showed blood in the spinal fluid in nearly 12 per cent, as reported by William Sharpe and Hines Roberts but only a few showed any clinical signs of birth injury

The hemorrhage is most often over the cerebrum and usually limited to one side beneath the dura but may be tentorial or from the large central veins.

Premature babies are especially liable to intracranial hemorrhage because of the thinness of the skull and the fragility of the blood vessels.

Hemorrhages of considerable size are apt to result in porencephalic cavities which were formerly considered to be developmental defects These are generally in the cortex and are due to tearing of tributary veins to the longitudinal sinus by the overlapping of the parietal bones as the head is compressed and molded during delivery

The clinical signs of intracranial hemorrhage in infants are usually asphyxia and difficult resuscitation The child is feeble does not nurse and may be more or less comatose There may be spasticity or convulsions. The fontanels may be tense or bulging A lumbar puncture should always be made in doubtful cases and if bloody spinal fluid is found under increased pressure the diagnosis is practically certain

The most common form of congenital cerebral spastic paralysis is paraplegia affecting both legs It is usually called Little s disease and was described by him in 1862 When the arms are also involved it is

known as diplegia Hemiplegia is almost as common Frank R. Ford, in his monograph published in 1927, states that true congenital cerebral diplegia is apparently not related to birth injury or to meningeal hemorrhage but is due to obscure developmental defects. The diplegias caused by injury or hemorrhage he prefers to call "bilateral hemiplegia."

The Acquired Form in Children

The acquired form of cerebral spastic paralysis in children is usually caused by infection, as from the middle ear or in the course of contagious diseases Direct injury to an intracranial blood vessel is an infrequent cause Spontaneous rupture of an artery and thrombosis and embolism are rare in children but common in adults.

The Acquired Form in Adults

Adult spastic paralysis of the cerebral type usually occurs in persons past middle life in whom a high blood pressure has existed for many years as a result of renal or cardiac disease Infectious endocarditis predisposes to embolism and syphilis is a frequent cause of thrombosis of the cerebral vessels Rupture of a vessel in the brain commonly called apoplexy is perhaps more frequent than embolism and thrombosis The resulting disability in all of these cases will depend upon the location and extent of the lesions If death does not result immediately or within a few days the general tendency is toward improvement in most cases a great deal of benefit can be afforded by the proper physiotherapeutic treatment.

Nearly all of the acquired spastic paralyses are unilateral and of the hemiplegic variety affecting the arm and leg of the side opposite to the cerebral lesion.

The more unusual diseases which may cause intracranial lesions need not be detailed in a work of this kind as the physical results and the physiotherapeutic treatment are practically identical with those mentioned before.

Treatment

In Children.—Considering first the ordinary cases of congenital cerebral spastic paraplegia or Little's disease it is of the greatest importance to determine the mental condition of the child before outlining the course of treatment. Children who are imbeciles or idiots can never become useful citizens and it is a difficult social and economic problem to decide whether to improve their physical abilities or to leave them as they are An idiot who is incapable of walking about may be less disadvantageous to a community than one who has full powers of locomotion On grounds of common humanity, however one might well hesitate to deny to any individual the help which medical science might afford. It is impossible in some cases to measure accu-

rately the mental capacity of very young children and it is also true that medical or surgical treatment of the spastic disabilities sometimes produces considerable improvement in the mental status For such reasons then public policy may dictate attempts to relieve even those who are severely handicapped.

In the absence of indications for cranial operations the plan of treatment involves certain fundamental principles

The clinical picture is that of an individual who has not, in the strict interpretation of the word a true paralysis of any of his muscles. Every muscle in his body is intact and is capable of the normal range of contraction and relaxation and the peripheral nerves both motor and sensory are undamaged The motor centers in the cortex however have been compressed and irritated or even destroyed by the cortical injury and are no longer able to transmit properly the desired stimuli to the motor nerves This results in a disarrangement in function of the muscles supplied by the damaged area of the cortex. Some of the muscles are overstimulated and contract too strongly The opposing muscles are understimulated and fail to balance these strong contractions The patient is unable to regulate voluntarily the unbalanced forces and an incoördination of movement naturally results

In the ordinary paraplegia of Little s disease the large calf muscles the gastrocnemius and the soleus become overactive and pull too strongly upward upon the heel producing the familiar equinus deformity of the foot. The child therefore walks upon the ball of the foot with the heel raised above the floor Similarly the great hamstring muscles in the thigh overbalance the extensors and cause flexion of the knee. In most cases the three adductors of the thigh also act too strongly and draw the knees together so that they interfere with or even cross each other

The treatment of this condition is carried out by frequent manipulation several times daily of the feet and legs the knee ankle and hip being put through the full normal range of motion and held in complete overcorrection for some minutes at a time The resistance of the muscles can always be overcome by firm steady pressure which will cause no actual pain whatever but which at first is often objected to by the patient. After the muscles have been relaxed and stretched by these manipulations an attempt is made to have the child perform some voluntary movements of a simple nature dorsiflexing the foot, extending the knee and abducting the thigh. Deep massage and kneading of the muscles may reduce their spasticity but must be done slowly and firmly because rapid and light tapping massage tends to increase, rather than to decrease muscular irritability

No form of electrical stimulation should ever be used in any variety of spastic paralysis Galvanism and faradism therefore are absolutely contraindicated.

No alternations of heat and cold as for example "contrast baths" should be used.

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After these operations the legs and feet are encased in a double plaster-of-paris spica, with the knees straight the feet in the neutral right angled position and the legs widely abducted In six weeks or less the spica is removed and physical therapy is again instituted.

The Hand—In cases of hemiplegia, the hand and arm may be seriously disabled and the problem of restoring function here is much more difficult than in the legs and feet because of the more highly differentiated character of the demands upon the upper extremity The elbow and wrist are usually flexed and the hand is apt to be deviated to the ulnar side with marked adduction of the thumb Voluntary attempts by the patient to perform movements with the hand or fingers cause incoördinated contractions of the muscles so that proper function is impossible A long course of faithful physical therapy and muscle-training must be persisted in and in some cases the results are very satisfactory It is of great benefit to tie the normal hand and arm behind the back so that the child is obliged to use the spastic hand for all purposes of work or play It is often difficult to obtain the cooperation of the parents in this procedure because of their undue sympathy with the struggles of the child to escape from the bondage. The hand should be incased in a long mitten or bag made of strong cloth or leather which is laced or tied to the wrist or above the elbow and is in turn fastened securely to the waistband in the back. When this can be conscientiously carried out it is the most successful method known to the author

In spite of all possible conservative measures of treatment and education there will remain a rather high proportion of patients who will not obtain sufficiently good function. For these considerable benefit may result from well planned and well-executed operative procedures The flexors of the wrist namely the flexores carpi radialis and ulnaris may be lengthened by open division When pronation of the hand is extreme the pronator radii teres may be divided or may be transplanted behind the radius so as to act as a supinator as in A H. Tubby's operation. It may also be necessary to cut the pronator quadratus, just above the wrist joint on the palmar side

The adducted position of the thumb due largely to overaction of the opponens pollicis is difficult to remedy Simple division of this muscle is not usually satisfactory It is probably better to cut the small branch of the median nerve which supplies this muscle the incision being made at the base of the thenar eminence

Undue flexion of the fingers is another stumbling-block. If the flexor tendons be lengthened by open operation the result is apt to be vitiated by a mass of adhesions all of the tendons becoming matted together with no possibility of individual action In a few cases the tendon of origin of the flexors has been detached from the condyle of the humerus with considerable benefit. This of course lengthens only the long head of the flexor sublimis but the dissection can be carried down to include the ulnar head of the flexor profundus Both of these muscles

Braces, splints and plaster-of paris casts are of little use in cerebral spastic paralysis They do not prevent contraction of the muscles, nor do they aid in locomotion. Their only field of usefulness is to immobil ize the extremities for a suitable time after operative procedures have been instituted as will be described later in this article.

The dominating factors of the conservative treatment are, first, to make the muscles flexible and relaxed by stretching and kneading and then to teach the patient to use the muscles in the proper manner Success can only be attained by constant effort and inexhaustible patience on the part of the attendant. Instruction carried out in classes is very valuable as the stimulus of competition and association with other similarly afflicted children leads to more rapid improvement. This is well exemplified at the Spaulding School for Crippled Children in Chicago where for some years a special department for spastics has been conducted with great success.

Later Treatment —Faithful perseverance in the conservative treatment should be continued for many months If it then becomes evident that the spasticity is too great to respond to the simpler measures operative interference should be considered

There are two distinct methods of operation which have stood the test of time

1 Lengthening of tendons and muscles
2 Reduction of nerve supply to the spastic muscles (Stoffel s operation)

Neither method produces perfect results in any case. Both methods lessen the spasticity very materially Tendon lengthening is easier and is not destructive. If too great lengthening should occur, the tendon can readily be shortened Stoffel s operation is difficult and technical, in comparison If too much of the nerve supply is cut off the damage cannot be repaired

A combination of the two methods is often more successful than the use of either alone.

In the writer's clinic the ordinary procedure is as follows Under general anesthesia the Achilles tendons are lengthened one-half to three-quarters of an inch by the open plastic method The biceps, semitendinosus and semimembranosus tendons are then exposed by incisions on both sides of the popliteal space and are cut across completely being allowed to retract as far as they may The child is then turned over on the back and the obturator nerves are exposed by a short incision downward from the spine of the pubis The fascia is separated exposing the adductor brevis and the adductor longus. Between these muscles the two branches of the nerve are easily found. In mild cases only the anterior branch need be divided In severe cases both branches are cut, and some operators remove a half inch or more of the nerves

readily be lengthened by operations performed under local anesthesia with a minimum of risk and in many instances with brilliant results

It will be noted that no mention has been made of Royle and Hunter's sympathetic ramisectomy nor of Förster's division of the sensory nerve roots. The writer feels that the ramisectomy is still of somewhat doubtful value and that Förster's operation should definitely be abandoned.

To sum up the views presented in this article the cardinal principles of treatment in cerebral spastic paralysis embrace

1 Early and long-continued training in the proper use of the affected extremities thus strengthening the weaker muscles.

2 Conservative efforts to reduce the spasticity by massage manipulations and stretching

3 Diminution of the power of the overstimulated muscles by lengthening their tendons (thus shortening their range of contractility) or by reducing their nerve supply

lie beneath the flexores carpi radialis and ulnaris, the palmaris longus and the pronator radii teres all of which can be, and in fact must be, detached at the same time The entire arm, forearm and hand are then placed in a plaster-of-paris splint, with the elbow in full extension, the wrist hyperextended and the hand supinated, for a period of five weeks. The educational and physical therapeutic treatment is then resumed.

As an alternative to the operation of lengthening the muscles and tendons, the selective nerve-division operations of Stoffel may be used. The nerves supplying the spastic muscles are exposed and one or more of the fibers running into the muscle bundles are cut across, or a section of them is removed This paralyzes a corresponding portion of the muscle, greater or lesser as the surgeon deems advisable. The results in many of these cases are excellent. The writer has not used this method as freely as have some of his confrères, because the operation is essentially a destructive one and its effects cannot be modified in case too many nerve fibers have been divided. It is also a somewhat inaccurate procedure, since it is impossible to determine precisely how much of the nerve supply to sacrifice in any individual instance. When a muscle or tendon has been lengthened too greatly, it is easy to shorten it the requisite amount, but when a small motor nerve has been sectioned it is practically impossible to repair it. The Stoffel operation, nevertheless is of great value when judiciously utilized in suitable cases especially in the adductors of the thighs the flexors of the fingers and the opponens pollicis

In Adults.—Cerebral spastic paralysis in adults, as a result of hemorrhage, embolism or thrombosis usually occurs suddenly, with profound constitutional disturbance Treatment of the peripheral disability must be deferred until the general condition is satisfactory The hemiplegia tends to improve rapidly at first, and then more slowly In many cases the medical attendant fails to appreciate the value of physical therapy in the treatment of individuals who have suffered a "stroke" and these unfortunates are allowed to drift along with a crippled hand and arm which might be made comparatively useful by proper therapy

The plan of treatment advised for hemiplegia in children is applicable also to adults Their coöperation is more easily secured in the physiotherapeutic measures but as many of them are advanced in years and are often not good operative risks it is not so frequently advisable to perform operations. Muscle-training is of great value in adults and is best carried out by rhythmical motions of both hands or both legs at the same time that is symmetrical synchronous movements rather than the use of only the extremity involved Persistence in the training will often result in unexpectedly good function.

In cases of disabling contractions or contractures of the calf muscles or the hamstrings it must be remembered that these tendons can

CHAPTER TEN

THE PHYSICAL THERAPY OF OBSTETRICAL PARALYSIS

JAMES WARREN SEVER, M.D

Obstetrical paralysis was first described by Smellie in 1768 but was brought to the attention of the medical profession in 1872 by Duchenne who described four cases.

The paralysis is due to the tearing of the cords of the brachial plexus as a result of forcible separation of the head and shoulder at birth This has been confirmed by operation by autopsy and by clinical observation The resultant paralysis is characteristic. The arm hangs limp at the side, with the elbow extended, the forearm pronated and the whole arm inwardly rotated The paralysis is always flaccid

It has been conceded by practically all observers that a difficult labor is a predisposing factor in the cause of this paralysis The labor is usually long and difficult and ether or forceps are used (Fig 1) All the conditions noted above imply the application of force, combined with great muscular relaxation of the child—conditions peculiarly favorable for the production of such an injury A moderately large number have had the head delivered naturally but the 'shoulder stuck and at that time force was applied

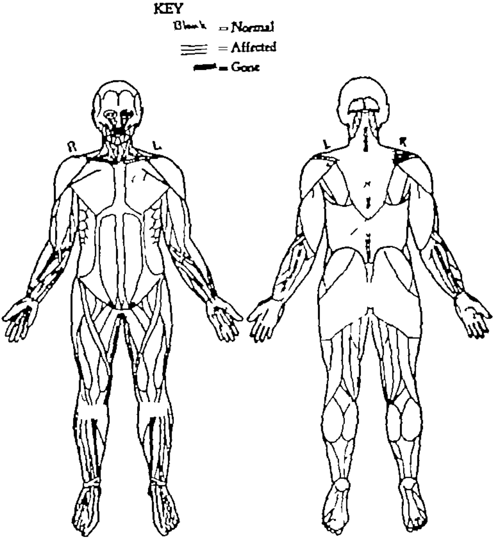
The presentations are generally vertex or of the face variety and about a quarter breech the latter classification including versions and footlings (Fig 2)

The condition of unequal pupils is probably overlooked in some cases and is a most important symptom in that it means definite injury to the two lower cords of the plexus and the first thoracic nerve which have communicating bands with the cervical sympathetic, or injury in the spinal cord itself The prognosis in these cases is usually not so good as in those which do not show this sign

TYPES OF PARALYSIS

There are generally recognized two distinct types of paralyses The more common consists of a lesion which involves the fifth and sixth cervical roots and the suprascapular nerve and produces a paralysis of only the muscles of the upper arm with the exception of the

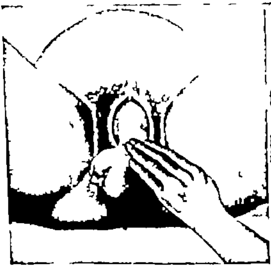
and possibly the first thoracic as well. Here the whole arm is flaccid there is a wrist drop and there is paralysis of the small muscles of the hand (Figs 8 9) There occurs also although rarely the pure lower arm type of paralysis in which there is no involvement of the upper cords of the plexus the so-called Klumpke s' paralysis In these whole



Figs 4 5—Chart showing typical upper arm type of obstetrical paralysis.

arm cases the paralysis is usually the result of stretching the plexus (Figs 10, 11) from overextension of the arm in head presentation and of injury to the lower cords of the plexus namely the seventh and eighth cervical and the first dorsal roots The paralysis may at times be bilateral It is in this type that one often sees inequality of pupils

supinators This is known as the "upper arm type," the so-called Erb's paralysis (Figs 3 4 5) The less usual variety the so-called "lower arm' or "whole arm' type (Figs 6, 7) is the result of injury not only to the fifth and sixth cervical roots, but to the seventh and eighth



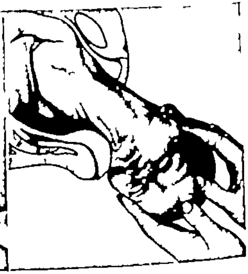


FIG. 1—Separation of head and shoulder with shoulder caught behind the pubes (Nagel.)
FIG. 2—Stretching of nerves by oblique traction when the shoulder is caught under the pubes.

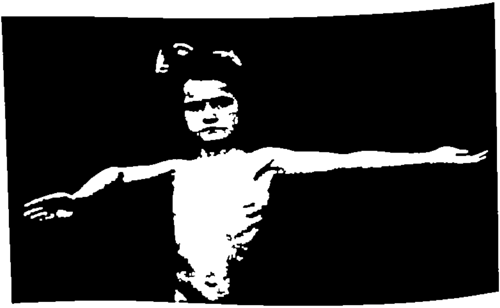


FIG. 3—Upper arm type of obstetrical paralysis before operation. Note inability to rotate arm outwardly t abduct, and t supinate Note flexion at elbow

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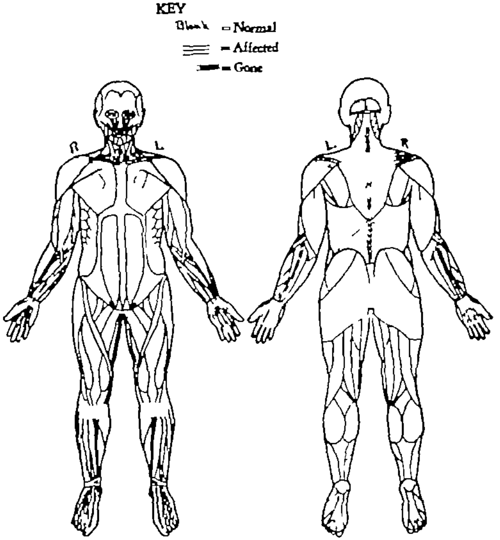


FIGS 4, 5—Chart showing typical upper arm type of obstetrical paralysis.

arm cases the paralysis is usually the result of stretching the plexus (Figs 10 11) from overextension of the arm in head presentation and of injury to the lower cords of the plexus namely the seventh and eighth cervical and the first dorsal roots The paralysis may at times be bilateral It is in this type that one often sees inequality of pupils

owing to the fact that the sympathetic fibers from the deep cervical ganglionic plexus enter the spinal cord through the first thoracic and at times through the eighth cervical roots Injury, therefore, to these roots leads to an uncontrolled stimulation of the motor oculi nerve.

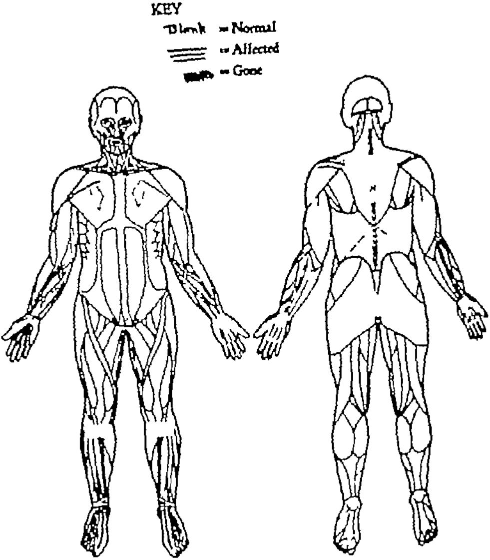


FIG. 6 7—Typical lower or whole arm type of obstetrical paralysis.

Conditions Resulting from Impairment of Function

Pathologically in the milder cases the stretching or tearing results in a greater or lesser degree of hemorrhage or edema into the nerve sheaths In others there may be a rupture of the perineural sheath, accompanied by hemorrhage into the substance of the nerve trunk associated with a tearing apart or a separation of the nerve fibers.

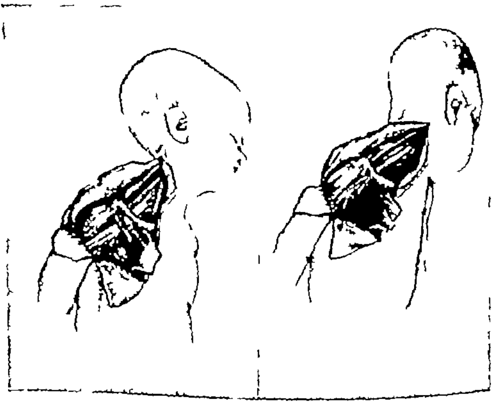
This latter condition leads of course to a permanent impairment of function and the formation of scar tissue in the nerve tract. In the more severe cases of the upper arm type there is a partial or complete division of the fifth and sixth cervical roots which leads to a more permanent form of paralysis than usual and the formation of a more extensive area of scar tissue

FIGS. 8, 9—Lower arm type of obstetrical paralysis, showing right arm held in extreme internal rotation in attempted elevation a characteristic position

It has been shown that traction and the forcible separation of the head and shoulder put the upper cords the fifth and sixth cervical roots of the brachial plexus under dangerous tension This tension is so great that the two upper cords stand out like violin strings Any sudden force applied with the head bent to the side and the shoulder held would without question injure these cords It has also been

shown that forcible abduction and elevation of the arm and shoulder put the lower cords of the plexus, the eighth cervical and first thoracic, on a stretch, and the application of much force may well lead to a tear rupture, or other injury to these segments. This condition is seen in breech cases with arms extended It may also follow sudden strain when the arm is elevated, such as the so-called "hostler's paralysis" caused by the sudden elevation and strain of the arm which occurs when a hostler holds a rearing horse

When the shoulder is held and the head is carried to one side, with the clavicle intact, considerable force is necessary to injure the



FIGS. 10, 11 —Diagram of brachial plexus. FIG. 10, head and shoulder in normal relation to each other The plexus is not on the stretch. FIG. 11 head and shoulder forcibly separated note the stretched position of the plexus, particularly the three upper roots.

plexus. The suprascapular nerve always gives way first, apparently because it has not so much freedom of play as the others A fractured clavicle, of course allows the weight of the shoulder to drag on the plexus and so predisposes to greater injury from traction Rotation of the head combined with forcible abduction apparently does not greatly increase the degree of tension on the plexus and certainly not enough to cause additional damage Most birth fractures occur in the

clavicle or in the humerus at about the junction of its upper and middle thirds.

At birth the shaft of the humerus is nearly wholly ossified but the two extremities are cartilaginous The scapula at birth is largely osseous with the exception of the glenoid fossa the coracoid and acromial processes and the posterior border and inferior angle, which are still cartilaginous It is on account of these conditions that fractures in these regions at birth are practically nonexistent. It is not possible to produce a paralysis of the Erb type by the fracture of any bone but the clavicle, and then the paralysis is due to the plexus injury itself and not alone to the fracture (Fig. 12)

Conditions Shown by X Rays —A study of roentgenograms taken in cases of obstetrical paralysis shows the following conditions

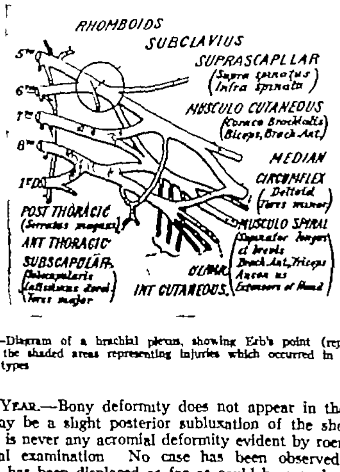


FIG. 12—Diagram of a brachial plexus, showing Erb's point (represented by a circle) and the shaded areas representing injuries which occurred in lower arm, or whole rm, types

FIRST YEAR.—Bony deformity does not appear in the first year There may be a slight posterior subluxation of the shoulder joint but there is never any acromial deformity evident by roentgenograms or clinical examination No case has been observed where the epiphysis has been displaced as far as could be seen by comparison with the normal shoulder The epiphysis as well as the shaft of the humerus is always smaller than the unaffected side a condition which is undoubtedly due to atrophy from disuse The scapula is practically

shown that forcible abduction and elevation of the arm and shoulder put the lower cords of the plexus the eighth cervical and first thoracic, on a stretch and the application of much force may well lead to a tear rupture or other injury to these segments This condition is seen in breech cases with arms extended It may also follow sudden strain when the arm is elevated such as the so-called 'hostler's paralysis," caused by the sudden elevation and strain of the arm which occurs when a hostler holds a rearing horse

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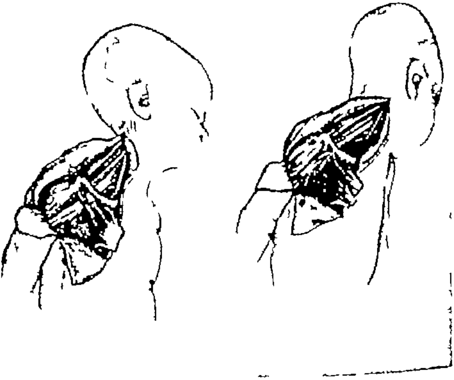

Fig o. —Diagram of brachial ple Fig o head and shoulder in normal relation t ea h ther The plexu i not on the stretch Fig t head and shoulder f rcibly sepa ted not the stretched pos tion of the plexus, particularly the three upper root

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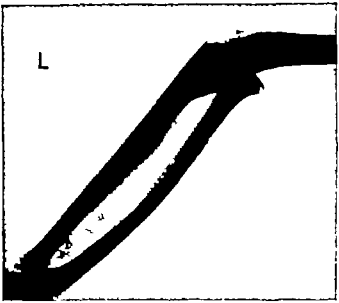

FIG. 14—X-ray of case of obstetrical paralysis, showing secondary deformity resulting from dislocation of head of radius.

FIG. 15—Typical upper arm type f obstetrical paralysis. Note inability to elevate bduct outwardly rotate and supinat hand and arm

always elevated and outwardly rotated, due apparently to the pull of the intact inward rotators and the levator anguli scapulae.

Later Years —As time goes on and the child gets older, one begins to see increasing evidence of bony deformity, occasionally more joint subluxation than at first, increasing outward displacement and elevation of the scapula, and acromial deformity The deformity of the

Fig. 13—X ray showing bony def rmity of the shoulder joint in a case of obstetrical paralysis f the upper arm type, marked hooking or elongation of the acromion, marked elongation of the coracoid process, and posterior subluxation of the head of the humerus. At operation both these bony obstructions had to be removed before the subluxation could be reduced

acromion consists of a bending downward and forward or a hooking of its outer end which apparently having no bony resistance to meet as normally in the head of the humerus projects downward in front of the posteriorly subluxated and inwardly rotated head (Fig 13) This hooking seems to vary directly with the degree of posterior subluxation and inward rotation of the humerus, and tends to increase as the child gets older provided subluxation is present.

of the upper arm type The arm lies limp at the side is extended and is inwardly rotated with complete inability to abduct elevate, outwardly rotate or supinate (Fig 15) The muscles paralyzed in the typical upper arm type are as follows deltoid supraspinatus infra spinatus teres minor biceps and supinator longus and occasionally the serratus magnus, coracobrachialis and supinator longus The arm cannot actually be flexed at the elbow but as a rule the lower arm is not affected so far as flexion and extension of the fingers go

Shoulder.—The inability to raise or abduct the arm at the shoulder is due to the paralysis of the deltoid and supraspinatus Outward rotation cannot be accomplished because of the paralysis of the infra spinatus and teres minor and the arm cannot be internally rotated because the internal rotators—namely the teres major the subscapularis and the latissimus dorsi—are already fully contracted due to lack of opposition (Figs. 16 17)

Elbow—The arm cannot be flexed at the elbow owing to the paralysis or weakness of the biceps brachialis anticus, coracobrachialis and supinator longus and supination cannot be carried out because of the inward rotation in which the arm is held and the weakness or paralysis of the biceps and supinator longus or brevis

Sensation—In regard to sensation it may be stated that it has been impossible in early cases to determine any changes from the normal on account of the age of the patient During the first week in early cases the child may cry if the arm is handled or moved especially in abduction but this soon disappears. In one or two cases some swelling and tenderness have been noted by palpation over the plexus above the clavicle This condition however apparently has no connection with the degree of paralysis present The hand grip is usually good and the child flexes and extends the wrist and fingers well.

Later Developments—The later developments in the upper arm cases, as the child grows older and develops with or without exercises and massage are as follows The persistence of the inward rotation and adduction deformity the so-called 'policemen s tip" position the inability in most cases to supinate fully or freely the inability to get the hand to the mouth without raising the elbow due to inability to rotate outwardly and the inability to put the hand to the head or behind the back.

Typical Lower Arm Conditions.—In the lower arm type all these conditions hold besides the additional ones due to the paralytic conditions of the lower arm and hand resulting generally in a useless dangling arm (Fig 18)

Deformity at Elbow—Contraction of the biceps and brachialis anticus always leads to some degree of permanent flexion deformity at the elbow, and not rarely to a subluxation or even a complete dislocation of the head of the radius (Fig 14) Persistence of marked loss of power in the triceps is not uncommon and may be a factor in causing this condition

Roentgenograms of the elbow practically never show any bony change of importance

It has been suggested that the flexion deformity is due to the consequent change in shape or depth of the olecranon fossa which conse

FIGS. 16, 17—Picture showing elongation of the acromio on the affected side.

quently acts as a bony block to full and free extension This is not so the limitation is wholly due to contraction of the anterior elbow muscles and can be corrected only by a subperiosteal lengthening of their structures as well as by a lengthening of the biceps tendon. Gradual stretching in a cast or turnbuckle splint might occasionally accomplish the same thing.

Typical Upper Arm Conditions—When the child is first seen, if within a few days or weeks after birth the following picture is classical

or adduction of the hand These cases *almost without exception* represent severe tearing injuries to the roots of the plexus and although some of the muscles may recover in part, particularly the upper arm and shoulder groups the lower arm cases practically never recover even after attempted operative repair of the plexus It is in these cases that sensation is more apt to be impaired than in the usual upper arm type

FIG. 9—Plaster cast t hold arm abducted, elevated, outwardly rotated and supinated.

TREATMENT

First of all *the use of electricity plays no part in the treatment of these cases* All kinds have been tried and all have been given up as wasteful of time and effort

Atrophy.—Atrophy of the muscles in these cases of obstetrical paralysis is never very marked except in some cases of the lower arm type. One never sees the extreme atrophy so noticeable in cases of infantile paralysis. This lack of marked atrophy is undoubtedly due to the fact that the nerve impulses are rarely fully blocked; thus the muscles practically never, except in rare cases, wholly lose their entire innervations. Some normal nerve impulses pass through the scar tissue at the site of the lesion, owing to incomplete destruction or injury of the nerve, and so keep the muscle tone up to a certain point. There is always a definite shortening of the arm in all cases, however, due probably as much to nerve injury as to lack of use.

Nerve Involvement.—In the classification of the whole arm or lower arm type are placed those cases which show any nerve involve-

FIG. 18.—Typical case of lower arm type of obstetrical paralysis. Note paralysis and contracture of hand.

ment beyond that usually shown by an injury of the fifth and sixth cervical roots. Pupillary inequality and narrowing of the palpebral fissure are not unusual with this type. Wrist drop is the usual condition associated with the usual inability to supinate, and the additional inability to extend the lower arm. Paralysis of the flexors and extensors of the wrist and fingers is common, associated with paralysis and atrophy of the intrinsic muscles of the hand. Often the proximal phalanges are hyperextended and the *distal* ones flexed, due to the paralysis of the interossei or lumbricales muscles. There is, of course, no power to grip and the fingers cannot be moved. There is usually ulnar displacement

FIG. 20—For flexion of fingers and arm action. "Here's a ball for baby big and soft and round."

FIGS. 21 22—For the supinators alone showing the two active exercises.

The treatment at once resolves itself into two divisions i.e., those to be treated with massage and exercises, principally those of the upper arm type, and those to be treated by operation on the plexus, usually those of the lower arm type Unless the early treatment has been adequate, the upper arm type will also come to operation not to repair the plexus but to correct contraction deformities. This operation, which has been devised by the author, will be discussed later

At first, in order to prevent contraction of unparalyzed muscles, it is best to put the arm at rest in a position where such muscles cannot become contracted This may be done by holding the arm in a plaster cast (Fig 19), or by using a light wire splint, in an abducted, elevated and outwardly rotated position, with the hand supinated. This position should be maintained between massage and gymnastic treatment, because it insures a better subsequent position of the arm. It also takes the drag off the paralyzed muscles, allowing them to regain their strength more quickly, and prevents subsequent shoulder joint deformity, such as subluxation and acromial hooking.

Massage and Exercises.—Massage and exercises are of the greatest importance and should be carried out daily if possible. It is most unwise to allow a child to become obsessed with the idea that it has an arm which cannot be used The mother is instructed to dress the paralyzed arm first but to undress it last She is told that each time she takes up the baby for nursing or other reasons, she should straighten out the fingers and wrist and supinate the forearm, as shown. Later she is shown how to abduct outwardly rotate and elevate the arm One has to be guided by the intelligence and adaptability of the mother as to when it is wise to allow her to perform these motions. A very good rule to give her is that she is not to do anything with the affected arm that she does not see the well arm do.

Passive and Active Exercises —The rhythm of exercise is of utmost importance One will find the singing of nursery rhymes while conducting the exercises advantageous in developing rhythm and in preventing the child from tiring of the exercise. Any suitable rhyme may be used, but must be sung with life and enthusiasm so as to impress upon the baby the association of the song or rhyme and the movement. It is surprising how early the child learns the association of ideas

As an example of this method, take the flexion and extension exercises for the fingers (Fig. 20) It is natural for a baby to play with its fingers so impress upon the child from the beginning that it has two hands.

Motions for Upper Extremity—The child is laid on its back on a padded table and the arm or arms undressed Beginning with the fingers and working up the arm and over the scapula, massage is

FIG. 20—For flexion of fingers and arm action. "Here's a ball for baby big and soft and round.

FIGS. 21 2—For the supinators alone, showing the two active exercises.

given to increase the circulation and nutrition. Then each finger and thumb, first separately and then collectively, is extended and flexed, at the same time some kindergarten or nursery song is sung such as

This is little Tommy Thumb,
Round and fat as any plum
This is little Peter Pointer (index),
Surely he s a double jointer
This is little Toby Tall (middle finger),
He s the biggest one of all
This is little Ruby Ring (fourth finger),
She s too fine for anything
And the little wee one Maybe (fifth finger),
Is the little finger baby

FIG. 23—For abduction at shoulder (with palms turned up, arm extended sidewise)

Then collectively

The little birdies in their nest
Go hop hop hop hop hop
They try to do their very best
And hop hop hop hop hop

This is just an example of flexion and extension exercises for the fingers To train the extensors of the wrist we sing

This way that way blows the weather vane,
This way that way blows and blows again,
Turning pointing ever showing,
How the merry wind is blowing

The emphasis is of course always put on the motion necessary to train the weaker muscle

Fig. 14—Elevation of arm starting position for Yards of ribbon and Ready rockets.

Fig. 15—Elevation of arm Ready Shoot fast

Fig. 16—F elevation and abduction f all shoulder group muscles. This is the same as rms upward stretch "Shoot

For the supinators (Figs 21, 22), sing

Roll over, roll over, so merry and free
My playfellows dear, come join in my glee.

Try to have the child meanwhile actively supinate, assisted of course, if necessary

FIG. 27—For abduction at shoulder Pump the water etc.

For flexion and extension at the elbow to exercise the biceps and triceps sing

Up down up down
This is the way we go to town
What to buy? To buy a fat pig
Home again home again rig a-gig-gig.

Of course at first, and for a long time one must not only actively assist the child with these exercises but must also perform them while the child is passive

For abduction at shoulder the position shown by Figure 23 is used except that the forearm is supinated With the exercises, sing

> One yard of ribbon
> Two yards of ribbon,
> Three yards four yards
> And tie a big bow on your hair

elevation of arm (Figs. 24, 25 26) sing

> Ready rockets! Shoot!

Repeat six or eight times This is the same as arms upward stretch Starting with the arms bent or flexed at elbow stretch straight above head with palms facing each other This is for exercise of all shoulder group muscles concerned in elevation and abduction

For abduction at shoulder hold the arm externally rotated semi flexed at the elbow with forearm supinated Bringing it to full abduction and then to body somewhat after the manner in which the old fashioned pump worked (Fig 27) sing

> Pump the water pump the water
> Pump pump pump

The exercises for the upper arm and shoulder may be carried out with the child lying on its back or if an older child it may sit up with its back against a straight chair or wall The scapula should always be controlled by direct hand fixation.

For external rotation hold the forearm flexed at right angles with forearm supinated and upper arm close to the body of the child (Fig 28) Then carry it back till the thumb touches the table (Fig 29) and returning to starting position describing a semicircle downward (Fig 30) sing

> Grind the coffee, grind the coffee
> Grind grind grind

While circumducting the arm sing

> Crank the auto (up)
> Crank, crank crank

This exercise stretches the adductors and internal rotators at the shoulder

This covers all the motions of the upper extremity Each case requires special emphasis on different motions This rests with the

For the supinators (Figs 21, 22), sing

Roll over, roll over, so merry and free
My playfellows dear, come join in my glee.

Try to have the child meanwhile actively supinate, assisted, of course, if necessary

FIG. 17—For abduction at shoulder Pump the water etc.

For flexion and extension at the elbow to exercise the biceps and triceps, sing

Up down up down
This is the way we go to town
What to buy? To buy a fat pig
Home again home again, rig-a-gig-gig

condition of the arm, and must be left to the operator s judgment, or the doctor s prescription for treatment.

When one finds a contracted pectoral, subscapularis or teres major one must be sure to fix the scapula while elevating and externally rotating the humerus A contracted pectoral in a baby may be over come by faithful treatment The older babies and children seen (one to twelve years) usually have contractures of the pectoral subscapularis and teres major and occasionally of the pronator radii teres These cases in addition to the treatment described are put up in a wire splint which fits over the pelvis and holds the arm in position of external rotation, semiflexion and supination These children should be given the exercise of hanging on stall bars or a trapeze.

Whole or Lower Arm.—In the whole or lower arm type it is advisable to give three months treatment, and if the fingers do not then show a tendency to recover it may be well to explore the brachial plexus and repair the nerves if possible. These cases are most discouraging No improvement is hoped for before a year I have seen a few of these babies begin to have the slightest amount of flexion of the fingers in from six to twelve months and very slowly improve. By the end of the third year they are beginning to build blocks It is the feeling of nearly all the medical profession that it is useless to do any nerve surgery in these cases When these children begin to get motion in their fingers they are taught to build with blocks (using colored blocks two inches square) put large colored pegs in a pegboard and string beads (the large colored kindergarten beads) A child suffering from upper arm obstetrical paralysis can be taught to build blocks as early as five or six months provided its training has been started early After the exercises the child is again given the arm massage to rest the muscles

Children naturally are imitators and live in the land of make-believe If the operator when treating a child between two and six years has sufficient sympathy with him she will find him of the greatest help in improvising games All she will have to do is to direct the execution of the movements so as to bring into play the muscles which she wishes to develop When treatment has not been started until after the child is a year and a half old the first thing the operator must do is to gain its confidence Once this is accomplished there is pretty clear sailing She should never deceive a child With tact sufficient patience and sympathy she can get it to try everything and to allow her to exert considerable strength in stretching contractures

The treatment should be continued for several years at least, and if contractures develop in the subscapularis and pectoralis major they must be divided before any further range of action in the arm is to be hoped for

Author s Operation.—Technic.—An incision is made on the anterior aspect of the arm beginning at the tip of the acromion and

FIGS. 28, 29, 30—Three exercises for external rotation of forearm as well as supination of hand.

condition of the arm, and must be left to the operator's judgment, or the doctor s prescription for treatment

When one finds a contracted pectoral subscapularis or teres major one must be sure to fix the scapula while elevating and externally rotating the humerus A contracted pectoral in a baby may be over come by faithful treatment The older babies and children seen (one to twelve years) usually have contractures of the pectoral subscapu laris, and teres major and occasionally of the pronator radii teres. These cases in addition to the treatment described are put up in a wire splint which fits over the pelvis and holds the arm in position of external rotation semiflexion and supination. These children should be given the exercise of hanging on stall bars or a trapeze

Whole or Lower Arm —In the whole or lower arm type it is advisable to give three months treatment and if the fingers do not then show a tendency to recover it may be well to explore the brachial plexus and repair the nerves if possible These cases are most discouraging No improvement is hoped for before a year I have seen a few of these babies begin to have the slightest amount of flexion of the fingers in from six to twelve months and very slowly improve By the end of the third year they are beginning to build blocks It is the feeling of nearly all the medical profession that it is useless to do any nerve surgery in these cases When these children begin to get motion in their fingers they are taught to build with blocks (using col ored blocks two inches square) put large colored pegs in a pegboard and string beads (the large colored kindergarten beads) A child suf fering from upper arm obstetrical paralysis can be taught to build blocks as early as five or six months provided its training has been started early After the exercises the child is again given the arm massage to rest the muscles

Children naturally are imitators and live in the land of make-believe If the operator when treating a child between two and six years has sufficient sympathy with him she will find him of the greatest help in improvising games All she will have to do is to direct the execution of the movements so as to bring into play the muscles which she wishes to develop When treatment has not been started until after the child is a year and a half old the first thing the operator must do is to gain its confidence Once this is accomplished there is pretty clear sailing She should never deceive a child With tact sufficient patience and sympathy she can get it to try everything and to allow her to exert considerable strength in stretching contractures

The treatment should be continued for several years at least, and if contractures develop in the subscapularis and pectoralis major they must be divided before any further range of action in the arm is to be hoped for

Author's Operation.—Technic.—An incision is made on the an terior aspect of the arm, beginning at the tip of the acromion and

carried down to below the insertion of the pectoralis major (Fig. 31) The cephalic vein is found generally in the outer edge of the wound and tied or drawn aside The tendinous insertion of the pectoralis major is defined raised on an instrument, and divided all the way across. The pectoralis major muscle is then retracted inward out of the way, giving one a clear view of the axilla and shoulder joint. The arm should now be abducted fully and rotated outward as far as possible.

Following the division of the pectoralis major, the range of motion in abduction will be greatly increased Outward rotation will, however

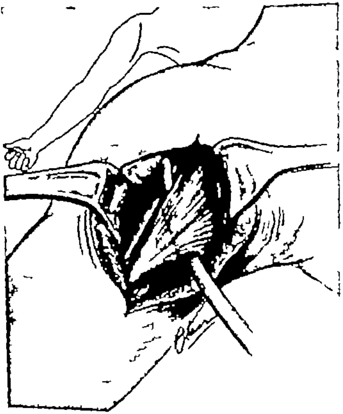

FIG. 31—Skin incision and isolation of pectoralis major Cephalic vein at outer edge of pectoral. Arm abducted and rotated out. Insert shows position of arm and line of incision.

be somewhat limited. With the arm fully abducted and outwardly rotated the insertion of the tendon of the coracobrachialis is to be defined This tendon is inserted on the coracoid process of the scapula. The tendon of the coracobrachialis obscures the insertion of the subscapularis It is therefore, necessary to separate the origin of the coracobrachialis from the coracoid process which in older children is generally much elongated by means of an osteotomy This allows the coracobrachialis to slide downward out of the way and gives one

a much clearer field to see the insertion of the subscapularis which then comes into view Just below this latter tendon are always found two or three small veins running parallel to the lower edge.

The best way to divide the tendon is to pass under it some blunt instrument and so define it It is of the utmost importance that the shoulder joint should not be opened (Fig 32) The tendon of the subscapularis should always be identified and lifted up before it is divided Blind cuts along the capsule do more harm than good and should never be made. Following the division of the subscapularis the

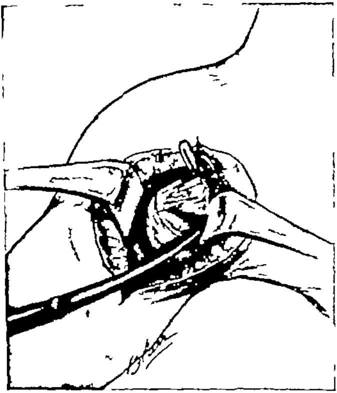

Fig 32—Sound under subscapular tendon The pectoralis major has been divided. The joint capsule shows t bottom of cavity

outward rotation and the abduction are entirely free If at this stage there is still some subluxation of the head of the humerus which cannot be fully reduced an osteotomy of the acromion should be performed and the loose distal piece either removed or tilted up to allow the head of the humerus to slip back into the glenoid The wound is then closed with a few stitches uniting the fascia and a silk stitch through the skin No drainage is required Usually very little bleeding takes place The arm is then placed on a wire splint, which holds it elevated to or above the shoulder level abducted and fully rotated outwardly with the hand in full supination (Figs 33 34)

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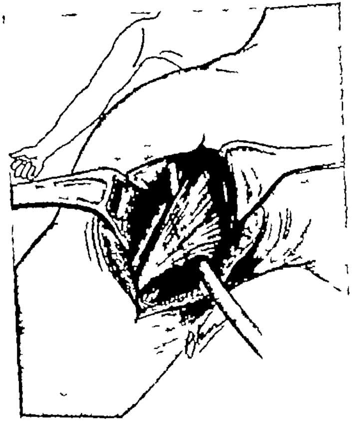

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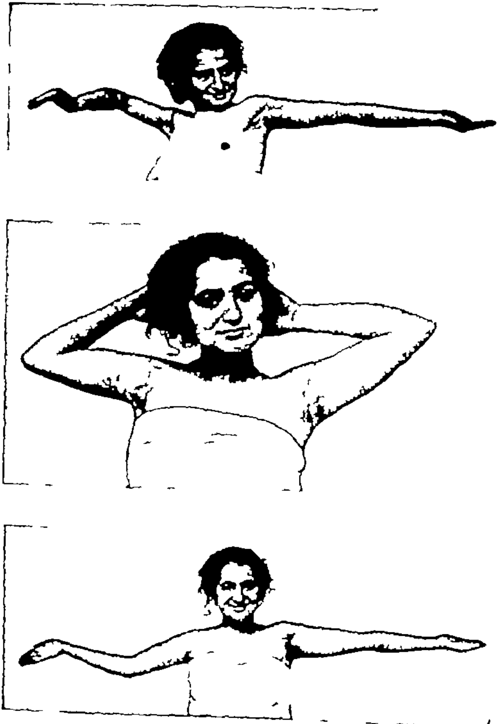
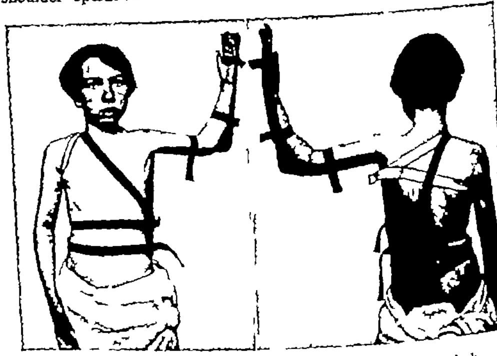


FIGS. 35, 36, 37—Obstetrical paralysis of right arm, upper arm type showing in ability to abduct outwardly rotate and supinate Fig. 35 before operation Fig. 36, after operation. Note bility t put hand to the head easily Fig. 37 one year after operation free bduction outward rotation and supination.

At the end of ten days' massage, baking and exercises are begun, and are continued daily, or at least four times a week. The splint should be worn night and day for at least three months.

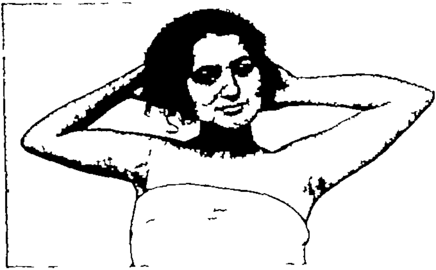
The operation merely releases contractions, giving the stretched and partly paralyzed muscles a chance to recover their tone and strength, and consequently the after treatment is of the utmost importance. In a certain number of cases it has been found advantageous to divide the pronator radii teres This muscle is often much contracted and, unless released it helps to prevent free supination and tends to cause the recurrence of its limitation This muscle may easily be found and divided by another incision on the upper forearm, subsequent to the shoulder operation

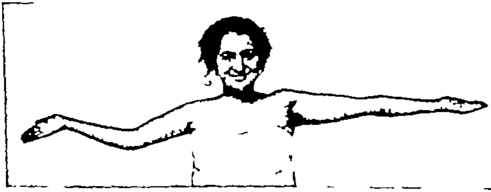


FIGS 33 34—Splint used after operation FIG. 33 front. FIG. 34, back.

Experience has shown that the operation on the plexus in the usual upper arm type of case is unnecessary In the lower arm type of case the situation is quite different. Also it cannot be too strongly emphasized that no operation on the plexus will be of any great use in restoring functional activity to the arm unless contracted and restricting muscles are divided and careful after treatment persisted in for a long period.

In the lower arm type of case operative treatment on the plexus has been done a number of times without any benefit. The plexus in all cases was found to be so badly torn and so bound down and invaded by scar tissue that no kind of repair was possible This may





FIGS. 35 36 37—Obstetrical paralysis of right arm, upper arm type showing in ability to bduct outwardly rotat nd supinate. FIG 35 before operation FIG. 36, fter operation Not ability t put hand to the head easily FIG. 37 one year after operation free abduction, outward rotation and supination.

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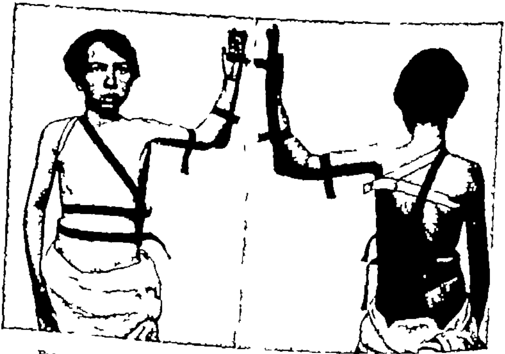

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CHAPTER ELEVEN

PHYSICAL THERAPY IN THE PREVENTION AND CORRECTION OF CERTAIN DEFORMITIES AND DISABILITIES OF THE EXTREMITIES

PHILIP LEWIN M.D F.A.C.S

INTRODUCTION

This chapter was written from the viewpoint of an orthopedic surgeon. The specialty of orthopedic surgery cannot be easily defined I have diagrammatized the definition as follows

Orthopedic Surgery is the Science of the	Prevention and Correction	of Deformity
	and the	
	Preservation and Restoration	of Motor Function

As an example of a disease which involves every factor in this definition I would cite infantile paralysis If deformity is not prevented it must be corrected If motor function is not preserved it will have to be restored Physical therapy is one of the most valuable agents in the preservation and restoration of motor and locomotor functions

The scope of this chapter includes conditions caused by congenital traumatic infectious neurologic circulatory metabolic, endocrine neoplastic and miscellaneous factors in so far as they have not been discussed in other chapters

Speaking in general terms the orthopedic surgeon is partial to the following physical therapy measures rest traction temporary immobilization support radiant heat, gentle massage active motion under water gymnastics sinusoidal current and diathermy

The reader is concerned with knowing and understanding and the orthopedic surgeon with discussing the indications for the use of physical therapy agents In what conditions physical therapy is indicated, when to start when to stop what to prescribe and when not to

have been due to two things first, to the fact that it was impossible to repair the plexus, and second, to the fact that, granted that the plexus repair was in part possible, the muscular contractures and joint deformities were not recognized and properly treated, without which the plexus repair would be a waste of time and effort.

VALUE OF OPERATION —The prognosis in all upper arm types of cases is good, provided the case is watched from the start and the treatment is properly carried out Practically all patients with upper arm paralysis are able to raise the arm to the shoulder level and can use the hand and lower arm well, except for varying degrees of supination (Figs 35, 36, 37) Abduction and outward rotation are rarely regained without division of the contracted muscles provided they have been allowed to contract.

In the lower arm type, the outlook is not so good, although many of the cases regain use of the upper arm in spite of the persistent paralysis of the lower arm and hand These cases should all be explored for repair of the plexus as far as possible, but even then very little hope can or should be held out to the parents. The general principles of treatment should, however, be carried out over a long period of time. Much can be done along orthopedic lines for these cases. They should not be generally neglected as they have been in the past, with the statement that nothing can be done or that they will get well without treatment.

A technician may be compared to an efficient midwife she may be very clever and capable but does not know the why or wherefore She must understand the underlying pathology of the conditions she treats

It is difficult to prove the value of physical therapy The explanation of the production of results is bound up in several factors some of which are as follows

1 The effect upon the circulation locally and generally
2 The local absorption of tissue products
3 Relief from pain
4 Relaxation of muscle spasm.
5 Release of adhesions
6 Increase in movements
7 Raising the threshold of the patient s resistance.
8 The psychologic effect during the various stages of disease injury or disability

It is within the limits of definition that the agents or agencies discussed in this chapter are physical therapeutic in nature or accomplish their effects by physical therapeutic phenomena.

Trauma

Trauma may be acute or continued Acute trauma may be mild or severe Continued trauma may be mild or severe As an example of mild continued trauma, one should consider the pianist and the ballet dancer Under severe continued trauma one may consider the iceman the plumber the piano-mover and other individuals who carry or lift heavy objects

Every movement of a joint causes trauma. If the circulation is good the effects of the trauma are repaired immediately If repair does not progress as rapidly as destruction a pathologic condition results If circulation is impaired the defect is not repaired and an area of pathologic change is formed

The joints most liable to trauma are those of the feet, the fingers wrist knee shoulder elbow and the hip

In a discussion of trauma one may consider trauma as the only factor trauma as the precipitating factor and trauma which exaggerates a preexisting condition As an example of trauma as the only factor one may consider fracture of the os calcis in a normal individual. As an example of trauma as a precipitating factor consider the case of an overweight woman of 50 years who has asymptomatic arthritis in both knees she falls and injures one knee lighting up an arthritis As an example of trauma exaggerating a preexisting condition one may consider a knee joint that has a low-grade arthritic condition which is affected by changes of weather but is perfectly serviceable until the woman falls on the sidewalk bumping her knee which results in pain swelling and disability

employ physical therapy It is very important to know what procedure to follow in the case of partially or completely stiff joints One must determine whether rest or movement is indicated. He must determine what type of rest, how long it is to be continued, whether it is to be intermittent or continuous or whether it should be accomplished by posture in bed, sandbags, slings traction, splints, braces or plaster-of paris casts If movement is indicated, what type of movement, at what intervals it is to be carried out, when it is to be started, and what are the danger signals When in doubt, one may try movements very cautiously and at infrequent intervals The reader is referred to other chapters on this subject and to the writings of Sir Robert Jones.

Physical therapy is more closely associated with orthopedic surgery than with any other branch of medicine because the orthopedic surgeon employs physical therapy in almost all his work. He is, therefore keenly interested in the progress and development of physical therapy

No orthopedic surgeon today can secure perfect results without the use of physical therapeutic agents If this statement is true concerning the orthopedic specialist one can readily understand how much more important it is to the general practitioner who is so often confronted with these same conditions.

Physical therapy aims primarily at treating the pathology, not the etiology of diseases, deformities and disabilities

Various orthopedic conditions in which the treatment of physical therapy may be of benefit are lumbago, sciatica, brachial neuritis, bursitis scoliosis poliomyelitis, spastic paralysis brachial palsy industrial conditions of the bones joints and nerves, and disturbances of the back knee shoulder and other regions.

The treatment should be under the supervision of the orthopedic surgeon. The coöperation of the patient is of paramount importance because so often the treatment is long and tedious.

The administration of physical therapy should be in the hands of a trained individual. By that is meant one who not only thoroughly understands the technic of all branches but has had in addition medical training in order to direct the treatment intelligently and to appreciate the dangers that may result from ignorance or from errors of omission and commission.

Physical therapy is an important therapeutic agent but it has its limitations and unless it is used with discretion much harm may be done and a valuable adjunct in the treatment of many surgical and medical conditions, especially orthopedic, may be lost to use through its falling into bad repute either as a result of exaggeration and unwarranted claims or of ill advised or improper administration.

Every physician should understand the principles of physical therapy and should understand the technic sufficiently well to be able to supervise the administration even when given by a competent assistant. In orthopedic surgery physical therapy is used as a curative agent as well as to restore or improve function

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Forms of Therapy

All forms of therapy, or treatment, can be divided into four types, viz

1 Medical
2 Surgical
3 Mental
4 Physical

All forms of therapy not included in the first three must, therefore, fall into Class 4

Class 4, or physical therapy, includes the following

1 Rest
2 Heat—thermotherapy
3 Fever therapy
4 Massage
5 Hydrotherapy
6 Electrotherapy
7 Heliotherapy—phototherapy—actinotherapy
8 Mechanotherapy including the respirator
9 Medical gymnastics—exercises, swimming underwater gymnastics
10 Occupational therapy—curative workshop
11 Support
12 Immobilization
13 Manipulative therapy
14 Aids in locomotion

Electrical apparatus is overrated and used frequently as a saver of time and manual labor No one method is a cure-all or advisable in every case

There are indeed very few practitioners of medicine and surgery who have sufficient information to advise the physical therapist exactly what to do for their patients. They should however, state the diagnosis the pathology and the reason for sending the patient to the physical therapist telling him what is desired in the way of treatment of the pathologic condition and whether it is an atrophy, an hypertrophy an exudate or whatever it may be

In prescribing physical therapy one should consider the situation analogous to sending a prescription to the druggist.

Daily treatment may be too frequent.

Many patients do not do well under ambulatory physical therapy who would if they were recumbent.

Advice to the physical therapist

Do not try to cure the patient in one or a few treatments, it cannot often be done

Do not discuss other cases or other doctors with patients or doctors

Do not talk too much.

Do insist upon knowing the pathology

Do carry out the doctor's orders like a druggist would fill a prescription

Beware of deep massage over hairy areas in cases of myositis of the neck and lower back.

The physical therapist too often uses his or her own hands instead of encouraging the patient to use his or her own muscles and move his or her own joints

The importance of the early application of physical methods of treatment is becoming increasingly appreciated It is important that physical therapy should be applied only by those qualified to do so by special training and experience A knowledge of anatomy and physiology is fundamental Much harm can be done and unfavorable criticism broadcast by misapplied physical therapy

Rest.—Rest includes rest in bed Rest to the body and limb is accomplished by the use of casts splints braces frames and sandbags

Bed—Recumbency —Most mattresses sag in the middle from the sides and both ends For that reason they should be made rigid by inserting boards or a wooden frame between the mattress and the spring In some cases a double mattress is desirable with the boards or wooden frame under the lower mattress This is of considerable value in back and leg cases especially for those patients who are in plaster of paris

Heat.—*Thermotherapy* is the application of heat or cold or both, alternately as a means of treatment. The chief agents are dry heat, moist heat, cold and alternate heat and cold The methods of administering these agents are as follows

Dry heat	Hot water bag Hot sand Hot brick Electric pad Electric lights—cabinet—baker Hot metal flask Hot chemical bag Hot air blower
Moist heat	Hot baths Hot applications with or without drugs Steam baths

Cold	Ice bag Cold applications Cold air blower
Contrast heat and cold	Bath Spray Applications

Heat may be produced by ointments, liniments and plasters

Plasters adhesive and bandages serve to retain the patient's own heat.

Pilocarpine, 1/10 of a grain hypodermically is frequently used in connection with heat in order to induce early perspiration.

The chief indications for thermotherapy are sprain, strain fibrositis, myositis, arthritis and after various traumas

In discussing radiant heat, Putti contrasts the effect of diathermy and the spirit lamp He believes that the so-called Bier box, which consists of a wooden case containing a current of hot air produced by a spirit lamp, is superior to diathermy He believes that the heat which produces this type of active hyperemia is the most effective form of physical therapy in the treatment of infectious or traumatic non articular arthritis Under the action of intense heat the pain diminishes, contractures relax, and the joint becomes more mobile.

Putti emphasizes the importance of active hyperemia The mechanism by which hyperemia acts is a complex one and not completely understood. Vasodilatation, by activating the interchange of body fluids increases the power of defense, contributes to the neutralization of toxins stimulates the processes of repair and by an inhibitory action on the nerve endings reduces the pain.

The steam or Russian room is one which is provided with live steam which is introduced beneath a table through perforated metal pipes. Its chief advantage is the production of increased cutaneous elimination The same holds true for the electric light cabinet.

Paraffin Wax Bath —I have seen the paraffin wax bath used to great advantage in the Royal Northern Hospital in Liverpool by Mr Armour It was used especially in industrial hand and foot cases. The temperature of the paraffin was about 104 F (40 C) The member was kept in it for about 20 minutes

Anodyne Lotion and Fomentations —In the treatment of nontuberculous painful, stiff joints the application of an anodyne lotion, used in conjunction with fomentations may be very effective in relieving pain and increasing movement.

My favorite lotion has the following formula

℞ Tinct. opii 30
Liq. plumbi subacet. dil. 40
Phenolis ½% 50
Ext. hamamelidis 60

M. et ft. lotio.
Sig. Externally as directed.

It is used in the following manner

Compartment A
1. Apply four layers of gauze over a wide area.
2. Saturate the gauze with the lotion after the bottle has been well shaken
3. Apply oiled muslin oiled silk or rubber sheeting

Compartment B
4. Apply flannel or wool wrung out of hot water
5. Apply oiled muslin silk or rubber sheeting.

Compartment C
6. Add hot water bottle
7. Cover everything with Turkish towels

If possible elevate the affected part. Change hot water bottle every two or three hours if necessary Add lotion to gauze three times a day

Fever Therapy—Fever therapy includes the reaction obtained by the intravenous injection of foreign protein such as typhoid vaccine, aolan and milk and subcutaneously by Coley's toxin.

The subject of fever therapy is discussed by Neymann in Volume I From the orthopedic point of view it is indicated in certain cases of arthritis and circulatory disturbances.

Massage.—Massage may be of various types as regards movements and force applied. Olive oil cocoa butter or talcum may be used to prevent irritation of the skin. Massage is useful in assisting nutrition and mobility

Massage is indicated especially in sprains strains dislocations, fractures stiff joints following amputation, following infantile paralysis, peripheral nerve injuries and occasionally in spastic paralysis

It is of real value in the preoperative and postoperative treatment of infantile paralytic conditions. Mennell says that in the treatment of recent injuries one cannot heal torn fibers by massage but he can assist in restoring the circulation upon which the repair depends

It is claimed for massage that it promotes metabolism maintains nutrition restores strength to weak muscles prevents formation of adhesions and helps break them up if already formed breaks up fibrosis, hastens repair after injury prevents and helps restore lost function in muscles and joints and renders voluntary motion in diseased or injured parts easier

Reference to various chapters in this series shows one the wide scope of usefulness of massage. Massage should be used as soon as possible and should be very gentle at first, gradually increasing in strength or severity

The contraindications for massage are hyperstheaia in poliomyelitis, pain and infection In cases of fracture or dislocation there is danger of displacing the bone fragments

Hydrotherapy —Hydrotherapy is the application of water at various temperatures and pressures and with various constituents.

Its value lies in the effect upon the circulation of the skin and the tonic action upon the nerves locally and generally The chief pieces of apparatus are the shower, needle-spray hose-spray and the sitz and whirlpool baths The last is a bath for the extremities in which the water is kept in motion

The application of hydrotherapy to the upper and lower extremities is valuable especially in sprains, strains and infections.

The Short Cold Bath —Riley presents a complete and instructive study of the effects of the short cold bath meaning a bath at from 90 to 55° F, for one-half to three minutes (usually one minute)

Electrotherapy —Flectrotherapy is the application of electricity as a therapeutic measure The chief types of currents as described by Kovacs are (1) the galvanic, (2) the interrupted galvanic, (3) the slow (galvanic) sinusoidal, (4) the surging or interrupted sinusoidal (modulated alternating), (5) the faradic (asymmetric) interrupted alternating (6) the high frequency (diathermy) and (7) the static. There is a great advantage in bed treatment as compared with ambulatory treatment. It is of greater value to bring the apparatus to the patient than to put the patient on a stretcher or in a wheel chair and transport him or her to the apparatus Diathermy and the galvanic current are the most valuable forms from an orthopedic standpoint. Electric cabinets bakers and lights owe their chief virtue to the production of heat.

The indications for diathermy consist in those conditions where deep heat is valuable such as in sprains and strains, synovitis, arthritis, myositis and fibrositis. Diathermy should be very carefully used in the presence of near or distant suppuration.

The Smart Bristow coil is an apparatus for producing graduated muscular contraction and is indicated in sprains and strains myositis, fibrositis arthritis and atrophy of muscles The present Smart coil which has recently found its way into America, through the efforts of Dr William O'Neill Sherman is a much larger apparatus and is probably the best means at the present time of producing graduated muscle contraction It is indicated in sprains, strains atrophy of muscles from disuse and disease from immobilization and various other factors and in arthritis especially of the atrophic type

Among the pathologic disturbances most amenable to diathermy are sprained joints inflammatory phenomena accompanying fractures simple arthritis and many forms of inflammation without suppuration in which heat tends to hasten the resolution of the inflammatory products and thus shorten disability Acute and subacute neuritis such as sciatic neuritis and myositis such as lumbago often respond extremely well to diathermy Certain forms of acute and subacute gonorrheal inflammation likewise yield more quickly under diathermy In these conditions relief from pain is one of the outstanding advantages of the treatment

In the chronic forms of arthritis the effect of diathermy is not so uniformly striking In many cases however partial or complete relief from pain and reduction of swelling is obtained

If diathermy treatment is instituted at a reasonably early date the trophic lesions in many cases of endarteritis or thrombo-angiitis obliterans or diabetes can be stopped and much damage prevented or mutilating operations made unnecessary

Heliotherapy —The subject of heliotherapy in tuberculosis has been covered by Rollier (Vol III) However there are many other conditions affecting the extremities in which heliotherapy is a very valuable agent. These include nutritional and circulatory disturbances arthritis myositis fibrositis and synovitis

Heliotherapy is of great value in toning up atrophic muscles Its value in nutritional conditions such as rickets is well known

Heliotherapy is of great value in atrophic arthritis It is surprising to see the excellent muscular tone of individuals who have been under heliotherapy for years Unquestionably if these patients had not had heliotherapy the enforced recumbency in bed would have resulted in marked atrophy of muscles and bones I prefer the term *helioaerotherapy*

Phototherapy means treatment by various lights The ultraviolet lamp is an imitation of sunlight but a very efficient one The exact action has not been determined The two main types are the quartz and the carbon

Lamps may be air cooled or water cooled The dosage of phototherapy depends upon the type of light used the individual characteristics i e. blonde or brunette the distance from the body and the duration of exposure

The principles of heliotherapy apply to phototherapy The infra red light owes its virtue to the radiation and penetration of heat

The quartz ray is better known as the ultraviolet ray It is called the actinic ray because it has the power to excite chemical action and has more effect upon photosensitive paper than other light rays and is called ultraviolet because it lies just beyond the violet of the visible spectrum.

The application of the ultraviolet ray is followed by two reactions —a local and a general one The local is manifested by various degrees of erythema, the general, by various blood chemistry reactions, the sum total of which may be said to be decidedly beneficial in many conditions

One cannot allow this opportunity to pass without calling attention to the fact that phototherapy has been used indiscriminately for any and every condition. This state of affairs is deprecated and should be condemned Ultraviolet radiation has considerable value from a physiologic point of view, but this has been greatly overdone and abused.

Phototherapy is indicated in atrophic muscle and joint conditions, in nutritional disturbances tuberculosis and arthritis, in recovery from fractures and sprains and strains In general, the indications and contraindications are similar to those for heliotherapy

Mechanotherapy —Mechanotherapy includes various mechanical apparatus which perform passive movements of the limbs, as illustrated by the Zander apparatus

The Europeans are more partial to this type of treatment than are the Americans. In most of the larger European clinics, one finds immense rooms with innumerable pieces of Zander apparatus. This apparatus is applicable to almost every type of injury and condition. One sees a patient having his thumb moved for him at a regular rate—another patient having his fingers moved at a certain rate and with a certain amount of force—another is having his foot supinated pronated dorsiflexed plantar flexed or circumducted. One sees a knee being flexed or extended at rhythmical intervals or a hip being abducted adducted, flexed extended or circumducted—a shoulder moved through its range of motion—another an elbow—another a wrist, and so on. There is no doubt that there is considerable value in the Zander apparatus but one should not lose sight of the fact that all physical therapy must be mixed with brains" in order to accomplish the desired results and there is no substitute for human hands and human brains. In America, one might say this form of Zander apparatus treatment has not been very popular Less cumbersome mechanotherapy has been developed especially by McKenzie. It is a valuable adjunct to the restoration of movement and function.

Respirator.—The Drinker respirator has been described in Volume I However from the standpoint of the orthopedic surgeon in the treatment of infantile paralysis it may be said that, in certain cases, if the Drinker apparatus is not at hand and functioning all the orthopedic surgeon s armamentarium may not save the patient s life. The indications are to carry a patient through a transitional stage of respiratory paralysis. It may be used in cases of intercostal paralysis to give those muscles a rest.

Medical Gymnastics—Exercises.—Medical gymnastics or exercises consist in muscle education and reeducation. Their chief value lies in the treatment of patients with infantile paralysis spastic paralysis brachial birth palsy scoliosis arthritis postural disturbances and neuromuscular conditions The equipment of the gymnasium consists of parallel bars upright bars wall ladders stall bars tables benches chairs wall mirrors wall exercisers traveling rings horses and floor mats

Active movements are those carried out by the patient. Passive movements are those performed by the physical therapist. The latter are employed chiefly when active movements are impossible because of weakness pain or lack of cooperation, or in the presence of adhesions that limit movement. Resistive movements are those performed by the patient against the resistance of the physical therapist and *vice versa*

Gymnastics include those performed on land and those in water

Swimming—Hydrogymnastics —Hydrogymnastics is a term coined by Lowman and includes special types of exercises performed in the water with and without support This valuable method is discussed in Volume III

Occupational Therapy —The importance of occupational therapy cannot be overemphasized.

The chief indications for occupational therapy in diseases deformities and disabilities of the extremities lie in the treatment of such conditions as fractures dislocations infantile paralysis spastic paralysis sprains and strains myositis fibrositis and arthritis

Because it involves active movements it may be employed at a very early period during treatment. The subject of curative workshops is treated in Volume I

By giving the patient purposeful acts to perform, making them very interesting and educational to him and by stimulating his ego one may accomplish very much It is very rarely that the patient will overdo to the extent of doing harm because he is guided by discomfort and pain

Mock and Abbey state that back injuries form a large percentage of the group in which physical therapy and occupational therapy combined can be of inestimable value to the surgeon In cases of nerve and tendon sutures muscle transplantation, infantile paralysis chronic arthritis osteomyelitis, tuberculous and nontuberculous joint disease occupational therapy has its important place In some cases the application is purely diversional while the affected parts are at rest In others the work consists in reeducating the joints, muscles and nerves to their normal functions For those who will not again be able to carry on their work a new set of muscles or nerves must be trained to function Neither physical therapy nor occupational therapy should be carried to the point of fatigue occupations should be given which

are best fitted to meet each peculiar condition of the case. The patient should be encouraged and stimulated, and his achievements recognized and rewarded

Support.—In the application of bandages, one must be very careful not to interfere with circulation In adhesive strappings, the important thing is to avoid constriction of circulation One should try to avoid in every case the complete encircling of a limb by one strip of plaster In the application of splints or braces, one may say that they may be used or abused, depending upon the skill and experience of the person who applies them. Splints and braces are not universal but must be individualized to the particular patient

Immobilization.—Immobilization includes bandaging strapping, splints, braces and casts

BANDAGES —Bandages are made of gauze muslin and variously woven materials which are resilient and therefore can act as support and compression It is important in the application of the bandage that no constriction of the circulation results. If the limb swells or becomes cyanotic the bandage is evidently too tight. There are various types of resilient bandages such as the Ace and the Tetra bandages. These bandages are woven so that the bandage acts as a resilient support. They have a definite place in the treatment of varicose veins and other circulatory disturbances There are combination bandages with adhesive on one or both sides.

SPLINTS —Various types of splints are illustrated in Figures 16 54 55 56 and 57

BRACES —Various types of braces are illustrated in Figures 7 11, 13 14 16 54 55 56 57 62 and 64

The surest way to get rid of braces is to put them on early and wear them faithfully until they are no longer necessary

CASTS —Every one who engages in physical therapy should know the principles of plaster-of-paris technic and how to handle casts, especially those that are bivalved.

Various types of plaster casts are illustrated in Figures 3 5 8, 10, 11 15 51 52 53 and 64

A cast never made a joint permanently stiff Any stiffness caused by a cast quickly disappears. It is the disease or trauma that causes stiffness. When the disease or trauma predisposes to joint stiffness, and early physical therapy is necessary to prevent stiffness the cast, if prolonged interferes with physical therapy and therefore, to that extent is responsible

Plaster bandages are usually made of crinoline or tarlatan into the meshes of which is rubbed the plaster-of paris powder The band-

age is then rolled and stored until used The most common type of crinoline is that whose meshes are 28 or 32 to the inch.

When ready for use the plaster bandage is soaked in a bucket two-thirds full of lukewarm water The addition of salt hastens and sugar retards the setting The bandage is laid on its side until all the air bubbles have ceased to appear at the top of the water which means that all the plaster has been saturated It is then lifed out both ends squeezed and twisted through a small arc, to get rid of the excess It is untwisted flattened out and the end of the bandage found and unraveled a few inches when the bandage is ready to be applied. Plaster of-paris bandages should be applied over one or two layers of stockinet. One layer of stockinet is most commonly used then a layer of sheet wadding then a gauze bandage and finally the plaster bandage If two layers of stockinet are used no other padding is used except over bony prominences such as the patella, the ankle bones and the heel One should be careful to pad the Achilles tendon region because of danger of causing pressure

One hears the expressions corrective' cast splint or brace. They are misnomers They are instruments of retention that is apparatus to maintain correction or overcorrection after those positions have been obtained by some other means such as manipulation or operation

Adhesive —Adhesive strappings are of value in sprains and strains. Adhesive strapping of a foot and ankle is found in Figures 40 41 42 and 43 lower back Figures 60 and 61 pelvis Figures 60 and 61 Other regions frequently strapped with adhesive are the metatarsal big toe little toe knee hip and chest.

Elastic supports for the metatarsal region the ankle the leg lower leg and the entire leg are of some value especially in those cases of circulatory disturbance in which there is swelling of the limb such as varicose veins and in traumatic conditions such as sprain and strain

Frames —The most common frames in use are those of Whitman and Bradford The Bradford type is a gas-pipe frame made usually of ⅜ to ½ inch gas pipe This is rectangular in shape with an elbow at each of the four corners Over this frame there is stretched a canvas The canvas may be in one two or three pieces

The Whitman type is a curved Bradford frame

A Balkan frame is an overhead structure consisting of four uprights corresponding with the posts of the bed—two longitudinal boards or bars and two cross bars It is used primarily for overhead suspension in cases of fractures A trapeze is suspended so that the patient may pull himself up

Aids in Locomotion.—These include crutches canes and artificial limbs

Crutches —Crutches are illustrated in Figure 1

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The patient usually learns the best manner of using one or two canes.

When one cane is used it should be placed on the weak or disabled side.

When two canes are used they should be used in a manner similar to that employed with crutches viz protrusion of the right cane then the left foot, next, the left cane and finally the right foot

ARTIFICIAL LIMBS —The subject of artificial arms and legs is discussed in detail in Volume II

Manipulative Therapy Brisement Forcé.—Manipulative therapy includes that performed gently and over long periods and that performed quickly under anesthesia. Local spinal or general anesthesia may be used

One should be careful in performing manipulation under anesthesia except in a few conditions

Brisement forcé may be used in a refracture of bones to correct deformity This was a common procedure during the late war

Manipulative therapy is indicated principally in those conditions which follow several weeks after an injury that is those conditions due to adhesions rather than to arthritis Manipulation is indicated in those conditions where because of a comfortable posture during an acute illness a person develops a contracture such as an adduction contracture of the thigh or of the shoulder or a flexion contraction of the elbow or knee

The following are brief outlines of the technic in manipulating representative joints

1 *Hip* With the patient completely anesthetized and the pelvis and opposite leg secured firmly to the table the affected hip is flexed with the knee flexed it is then extended then flexed with the knee extended It is then adducted abducted extended with the knee extended circumducted, then rotated inward and outward It is then hyperextended over the edge of the table In some cases the adductor tendons must be divided before abduction can be performed.

2 *Knee* With the pelvis and the other limb held firmly the knee is gently flexed then extended two three or four times it is not used as a pump-handle In all cases of manipulation of the knee one should see that the foot and the hip on the same side can be put through the normal range of movements

3 *Ankle* Manipulation of an ankle includes dorsiflexion plantar flexion, inversion eversion supination pronation circumduction dorsiflexion and supination at the same time are the *sine qua non* in manipulation of the ankle

4 *Foot* Manipulation of the foot includes that of the subastragalar joint through the tarsal joints through the tarsometatarsal joints

Crutches are measured for adults by subtracting 16 inches from the height of the individual Another method is to measure the distance from the axilla to a point 8 inches outward from the outer border of the foot. Crutches come in even sizes only and, if odd sizes are used, the larger size should be prescribed and then cut off Rubber tips

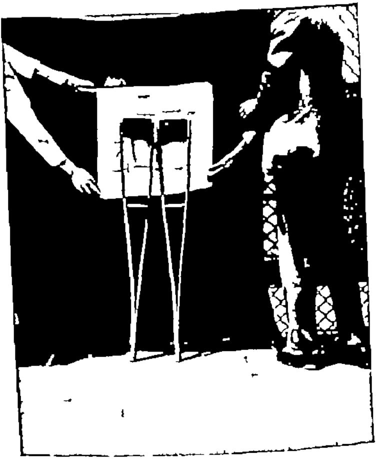

FIG. —Special type of crutch. Substitution of a brachial cuff for the axillary rest.

should be applied and axillary pads should be added to that portion to prevent irritation and crutch palsy

If a patient is allowed to bear weight on both legs, the proper method of progression is as follows place one crutch forward, then the opposite foot then the second crutch and then the remaining foot. If a patient walks with crutches and one leg he should put both crutches forward then the leg the affected leg either held flexed or preferably with a block under the shoe (heel and sole) of the well side in order to keep the injured part off the ground without tilting the pelvis and spine.

CANES —Canes are used during the stage after crutches are no longer necessary They may be used in minor conditions where crutches are not required

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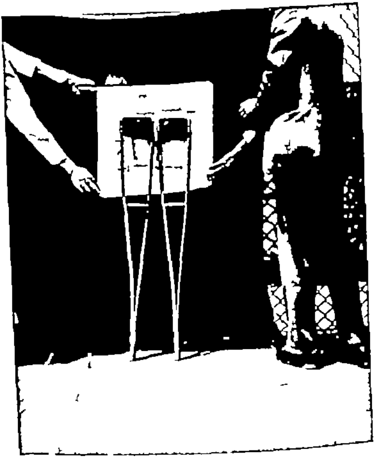

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FIG. 2 —Extreme type of congenital clubfoot talipes equinovarus in a boy of 1 years, who had had n treatment. N te the large bursae in the regions of the cuboid bones. (Courtesy of Dr John L. Porter)

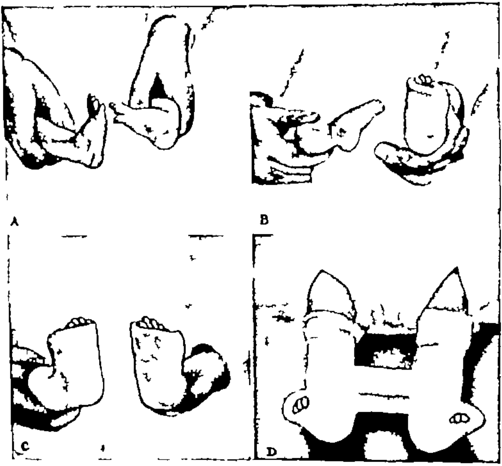


FIG. 3 —Lewin type of cross-bar cast for congenital club feet. A congenital club feet in a child 1 days old B one foot corrected and in plaster cast C, both feet corrected; D cross bar made of tongue depressors to maintain utward rotation of the legs.

and through the metatarsophalangeal joints In the metatarsal joints the important consideration is plantar flexion.

5 *Shoulder* With the patient entirely flat and secured to the table, the shoulder is first manipulated gently in forward flexion with the elbow flexed then forward flexion with the elbow extended, forward flexion with the forearm both in supination and pronation, gentle abduction, forced abduction (holding the scapula firmly), backward extension of the arms circumduction of the shoulder and complete internal and external rotation The most important movements that must be obtained are abduction and external rotation.

6 *Elbow* The elbow is flexed and extended three or four times with the forearm both in pronation and supination

7 *Wrist* The wrist should be dorsiflexed, palmar flexed forced laterally radialward and ulnarward, the important considerations are dorsiflexion and supination

8 *Hand* The hand must be manipulated so that it can be put in the position of grasp—as though it were grasping a tumbler

9 *Neck* In manipulating the neck one should be very cautious. Produce gentle flexion of the head, extension of the head lateral bending so that one ear almost touches the shoulder of the same side, then the other side then gradual rotation to the right and rotation to the left. The reader is warned that manipulation of the neck is one of the most delicate and it may be one of the most harmful, procedures to which an individual may be subjected.

The conditions which may cause disabilities and deformities of the extremities constitute a very long list, most of which have been mentioned in other chapters Those not discussed in detail will be included in this chapter Special conditions include congenital, infectious traumatic, mechanical static, postural, neuropathic and functional disorders

Congenital Defects and Deformities

Under congenital defects and deformities, the most important to be considered are clubfoot and congenital dislocation of the hip

Clubfoot

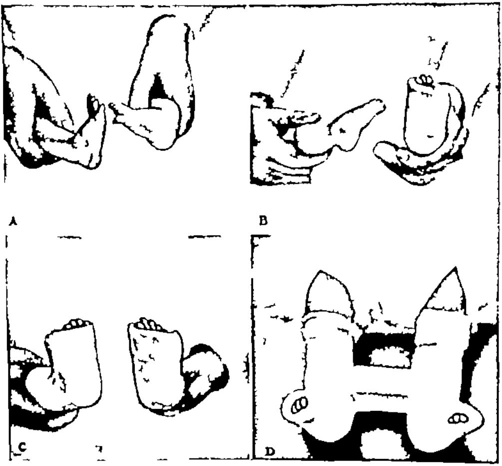
Clubfoot may be congenital or acquired

In clubfoot the two main types are congenital equinovarus and calcaneovalgus.

$$\text{Tallipes}\ \begin{cases}\text{equinus}\\ \text{calcaneus}\end{cases}$$

$$\text{Tallipes}\ \begin{cases}\text{equino}\begin{cases}\text{varus}\\ \text{valgus}\end{cases}\\ \text{calcaneo}\begin{cases}\text{varus}\\ \text{valgus}\end{cases}\end{cases}$$

FIG. 2 —Extreme type of congenital clubfoot talipes equinovarus in boy f 12 years, who had had no treatment. Note the large bursae in the regions of the cuboid bones. (Courtesy of Dr John L. Porter)



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taneous reduction. In the older cases treatment includes manipulation under anesthesia retention in plaster casts which are changed in periods ranging from 3 to 6 months then follow up treatment which includes exercises and baths such as the brine bath of Denucé and the Galeazzi Putti and Ridlon manipulations Open operations are required in those cases which cannot be reduced by the closed method or in those hips which will not stay reduced by the closed method

The chief manipulations or maneuvers for the reduction of congenital dislocation of the hip include those of Paci Lorenz, Galeazzi Putti Ridlon Bradford Davis and Calot. Every textbook of orthopedic surgery describes some of these methods At the time of change of the cast and following its final removal bathing of the hips and lower extremities in warm water and application of heat followed by gentle massage are indicated As a rule these patients can be trusted to return the legs to normal position by being allowed to exercise them cautiously especially in warm water

CONGENITAL DISLOCATION OF THE KNEE

Congenital dislocation of the knee is a rare deformity characterized by genu recurvatum or a backward curving of the knee joint The early treatment consists in gentle manipulation to flex the knee and the application of a splint or plaster cast to hold it in the flexed position

MacFarland and McMurray have devised an operation sectioning part of the quadriceps femoris muscle followed by flexion of the knee If the child is seen and treated very early operation is rarely necessary

CONGENITAL DISLOCATION OF THE SHOULDER

Congenital dislocation of the shoulder is a very rare deformity There are not more than 25 instances reported in the literature several of which are not authentic. The treatment consists in gentle manipulation and retention followed by physical therapy including gentle massage and more gentle movements.

CONGENITAL FLATFOOT

The etiologic factor of importance in congenital flatfoot is heredity It is more often transmitted from the father s than the mother s side The importance of the accessory scaphoid should not be overlooked This is an adventitious bone in the region of the tarsal scaphoid. The important factors are the early recognition and early treatment. The best early treatment is a plaster-of paris cast maintaining the posterior portion of the foot in supination with the fore part of the foot in pronation that is the posterior half of the foot should be tipped outward

The treatment may be divided into early, intermediate, and late. Treatment includes manipulation, overcorrection and retention in casts, braces or splints. In the final stages of treatment, one prescribes proper shoes with modifications, exercises, massage and manipulation.

When one finds congenital equinovarus, he produces a calcaneovalgus and *vice versa*

Pes planus is flatfoot Metatarsus varus is "pigeon toes." About 75 per cent of congenital clubfeet are of the type in which the toes are pointed downward and inward This type occurs once in about 1000 births, 65 per cent are in males and 57 per cent are one-sided.

The deformity is usually said to be due to position *in utero*, heredity is found to be a factor in 5 per cent of the cases. About 30 per cent of the cases are in the first born.

The chances of cure depend upon the age, the type and degree of deformity; the degree of rigidity the proper treatment and the persistence of the treatment and observation Active treatment may be necessary for months, and care and supervision for years. The long narrow foot is much more amenable to treatment than the short chubby foot.

Treatment.—The treatment for clubfoot may be applied at birth, during infancy, during childhood or in adult life, but the earlier the better The object is to correct the deformity as soon as possible and to maintain the correction until proper use of the foot has made it permanent. Some form of treatment should be instituted immediately The means of correcting the deformity are manipulation (with or without anesthesia) the use of casts and braces, and operation. Operation is rarely necessary when the patient is seen soon after birth. The various methods of retention consist of bandages, adhesive strapping, plaster-of-paris casts and braces

I cannot recommend too strongly the use of plaster of paris (even though the infant be but one hour old) to retain a foot in the corrected position which has been obtained by gentle manipulation. Massage exercises and modification of shoes are other measures of importance. In older individuals, operations on the bones, tendons and other tissues may be necessary

In clubhand the treatment includes manipulation retention massage further manipulation braces and exercises. Operation may be necessary

CONGENITAL DISLOCATION OF THE HIP

Congenital dislocation of the hip is the most important congenital dislocation. The displacement may be upward backward or forward. The most common is upward and backward. Early treatment includes what Putti has described as a triangular frame which is attached to the child s legs so as to produce abduction which usually results in spon-

FIG. 6.—New born baby with brachial birth palsy of the left arm treated by means of a padded wristlet and a strap attached to the head of the basket to maintain abduction of the upper arm.

FIG. 7—Brachial birth palsy in a child of 18 months brace maintaining abduction and external rotation of shoulder flexion of elbow supination of forearm dorsiflexion of wrist and extension of fingers.

FIG. 4.—Spastic paraplegia (Little's disease) illustrating adductor spasm producing cross-legged progression.

FIG. 5.—Plaster-of-paris casts of both legs with a cross bar maintaining abduction, in a child who had adductor spasm due to spastic paralysis. She was treated by obturator neurectomy. In some of these cases tenotomy of the adductors is also required.

sprain strain, rupture of muscles rupture of tendons flat feet, knock knees and bowlegs These conditions are described at length in other chapters

FIG. 8—Traumatic right flatfoot (a) front view (b) rear view (c) corrected in a plaster cast.

In regard to trauma and postural cases practically all physical therapy agents have been discussed in the chapters on fractures and dislocations in joint injuries (Vols II and III)

SPRAINS AND STRAINS

It has been stated that a sprain is worse than a break." This is grossly untrue because most sprains are mistreated. The proper treatment for a sprained ankle for example, is absolute rest and elevation of the limb the application of cold and a compression bandage In athletic individuals weight bearing should be encouraged In others it is contraindicated.

Mennell advises early movement and massage without fixation

Smart advises the early use of graduated muscle contractions by means of his electric coil and no immobilization

RUPTURE OF MUSCLES

In cases of rupture of a muscle the early diagnosis is important. The treatment includes rest relaxation of the muscle application of cold and retention support. Recently it has been advised to inject novocaine into the muscles to cause relaxation Heat massage and gentle active movements are indicated.

and the fore part of the foot tipped inward so that the big toe rests on the cast The cast should be replaced every two or three weeks. It may be followed by adhesive strapping or, preferably, a brace. Modifications of the shoes are very important and consist in building up the inner border of the heel and the outer border of the sole. Felt pads in the shoes are of value in supporting the longitudinal arches. Exercises should be started as soon as the child can comprehend Massage is important and contrast sprays may be used for older children.

SPASTIC PARALYSIS

The causes of spastic paralysis are intra and extra uterine. The intra uterine causes are defects or conditions within the skull, such as cysts and hemorrhage The obstetric causes are trauma during, and immediately after, birth. The latter is illustrated by vigorous efforts at resuscitating a "blue baby" The treatment consists in prophylaxis and curative measures, prophylaxis including gentleness in delivery The curative measures include the following lumbar puncture, operation swimming stretching of contracted structures, walking, using a walker or crutches braces and neuromuscular training

In the treatment of spastic paralysis one should emphasize the value of heat in order to relax muscles withholding massage, using gentleness in handling the patients, to the extreme degree, and active movements A movement directed by the brain and carried out by the proper muscle or group of muscles, with no overflow of nerve impulses producing purposeless movements is the acme of performance

Lowman has emphasized the value of a 10 per cent increase in temperature of the water used in swimming over that used for poliomyelitis cases

BRACHIAL BIRTH PALSY

In brachial birth palsy the important points are early recognition and early treatment. A new born child with the diagnosis of brachial birth palsy should have its arm suspended from the top of the crib by a sling in the form of suspension guy ropes A very simple wire brace of the Sever type should be made Physical therapy follow-up includes massage and gentle manipulation Operations are necessary in certain cases They usually are required in those cases that have been neglected. The most important operation is the one known by the name of Sever in which the pectoralis major and the teres minor tendons are cut. In some cases the coracobrachialis and subscapularis are also released. Kleinberg has recently advised a capsule plastic operation which is evidently very beneficial.

TRAUMATIC CONDITIONS

Traumatic conditions include industrial occupational mechanical or static These include fracture dislocation fracture-dislocation

RUPTURE OF TENDONS

Rupture of the tendon often requires suture which should be done early so that active motion can be instituted as soon as possible. Splints heat, massage and gentle active movements are indicated.

FRACTURES

In the treatment of fractures one must emphasize the importance of rest, reduction retention early active motion heat and physical therapy Some advise occupational therapy as being of greater value than physical therapy

This subject is discussed at length in Volumes II and III

DISLOCATIONS

(See Lindsay and Brown Vol. III)

Conditions of Infectious Origin

Infectious conditions include tuberculosis syphilis Charcot s joint, syringomyelia, infections with pus organisms infections with unusual organisms osteomyelitis infantile paralysis and encephalitis

The physical therapeutic measures that are of value in infections are heat, in the form of radiant heat or fomentations elevation ultra violet and roentgen ray therapy and hydrotherapy in the form of packs One must be careful to prevent contractures deformity and adhesions. The technic of incisions and drainage is not included in this chapter

TUBERCULOSIS

In the treatment of tuberculosis of bones and joints the important factors are rest, proper splinting prevention of deformity correction of deformity if it has occurred and preservation of function or the restoration of function if it cannot be preserved

In the treatment of tuberculosis of bones and joints many physical therapeutic agents are of great value These include rest, recumbency support, immobilization plaster-of paris casts braces therapeutic baths heliotherapy phototherapy and occupational therapy

Arthrodesing or stiffening operations are of great value. They are performed on the spine hip knee ankle, shoulder elbow and wrist. The reader is referred to textbooks of orthopedic surgery for descriptions of these operations

Fig. [illegible].—Lewin method of treating fracture of the clavicle in young children, illustrating the method of maintaining backward displacement of the shoulders by means of metal or wood bar. While the bar is in place a figure-of-eight double spica is applied. This allows free motion of the arms. For a day or two it is advisable to apply a sling. In this method of treatment a plaster-of-paris double spica may be used.

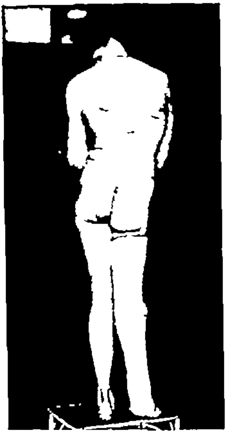

Fig. 11.—A girl of 6 years who had infantile paralysis t the age f years. Note total right scoliosis with the shortening f the right leg, which produced an inequality of the gluteal creases and dimples in the regions of the posterio superior iliac spines.

Fig. 1.—Extreme type of infantile paralysis with high degree of deformities and disability.

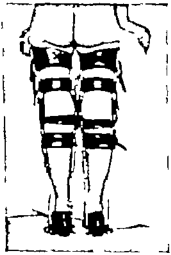

Fig. 3.—Calliper braces with lock joints at the knees used on a patient wh had infantile paralysis.

Fig. 14.—Two long leg braces and a body brace for extensive paralysis due to anterior poliomyelitis.

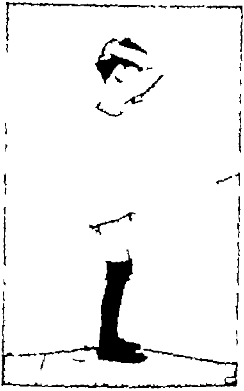

FIG. 10.—A boy of 10 years with tuberculosis of the spine treated by a Hibbs' spine fusion followed by a body cast.

SYPHILIS—CHARCOT JOINT

In the treatment of syphilis one must be careful to prevent deformity and if deformity has occurred, it should be corrected. The various physical therapeutic means included are massage, splinting, braces pyretotherapy and diathermy Specific treatment including malaria and arsphenamine is not discussed in this chapter

OSTEOMYELITIS

In the treatment of osteomyelitis three methods will be briefly mentioned

1 The Orr method which includes good surgery, vaseline pack and plaster-of-paris casts. The principle of this includes rest of the wound by means of the vaseline pack and rest of the limb by means of the cast No sutures are inserted as a rule

2 The method popularized by Baer which is the treatment by means of maggots called the "living scavenger treatment." By a special process the eggs of the maggot are sterilized and the live maggots are inserted into the wound There are numerous reports of excellent results following this method

Fig. 16—Hand splint to maintain abduction and extension f the thumb, but permitting flexion of the distal phalanx.

portant in order that a strong group of muscles may not overcome a weak group

In the case of a shoulder the arm should be abducted to a right angle for most of the day and night being released four or five times daily and placed in adduction for a few minutes each time One must be on guard to prevent contracture in adduction and internal rotation.

The elbow should not be allowed to develop a flexion contraction the wrist should be held in dorsiflexion and the fingers in the position of grasp One must guard against pronation deformity One should be

3 The aluminum and potassium nitrate treatment is the use of this chemical done into a poultice using rolled oats, which is applied to the limb There are reports of excellent results following this method

The physical therapeutic measures that may be of value in some cases of osteomyelitis include phototherapy, heliotherapy, the carbon arc lamp and occupational therapy One must endeavor to maintain muscle tone and counteract atrophy of muscle. Transfusion of blood is indicated in some cases

ANTERIOR POLIOMYELITIS

In the treatment of anterior poliomyelitis, or infantile paralysis, physical therapeutic measures are indicated in every stage, including the preparalytic, paralytic, subacute and chronic. During the prepara-

FIG. 15—Double abduction spica cast to be used as a model for making a brace Patient had bilateral deltoid paralysis due to anterior poliomyelitis.

lytic stage convalescent serum is probably the most important agent. During this stage the importance of bed positions or bed posture cannot be overemphasized Proper bed position including the maintenance of bones and joints in a position of neutral muscle pull is very im-

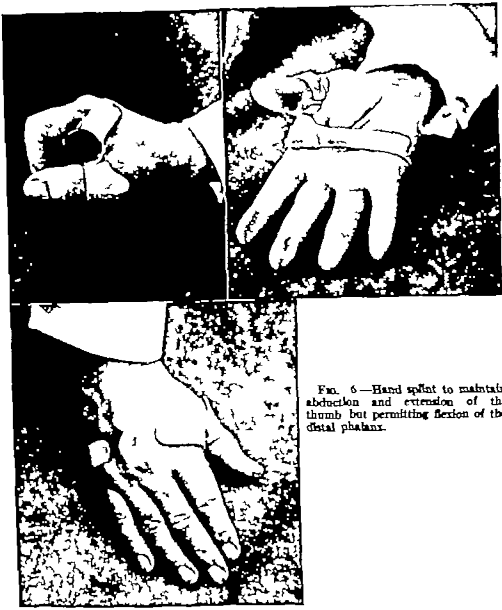

FIG. 6—Hand splint to maintain abduction and extension of the thumb but permitting flexion of the distal phalanx.

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In the case of a shoulder the arm should be abducted to a right angle for most of the day and night being released four or five times daily and placed in adduction for a few minutes each time One must be on guard to prevent contracture in adduction and internal rotation.

The elbow should not be allowed to develop a flexion contraction the wrist should be held in dorsiflexion and the fingers in the position of grasp One must guard against pronation deformity One should be

very careful, if the thumb muscles are involved, not to allow deformity to occur

Bed positions are maintained by means of pillows, boards at the foot of the bed, boards under the mattress sandbags salt bags, casts, splints and braces When the patient is ready for walking, crutches or a special walker is to be used

The causes of deformity are unequal muscle pull, the effects of gravity and the early use of weakened muscles. The cause of disability is weakness of the muscles The various physical therapy agents include medical gymnastics, massage, exercises contrast sprays, neuromuscular reëducation and underwater gymnastics. I have in a few cases used fever therapy that is, intravenous injection of typhoid vaccine

ENCEPHALITIS

The important factors to be mentioned here are the prevention of deformity, the correction of deformity and the prevention of disability The agents used are casts, braces splints crutches and canes Neuromuscular reëducation is very important. Operations on sympathetic nerves are often of value.

Conditions of Mechanical or Static Origin

The mechanical or static group of conditions include flatfoot, metatarsal depression pes cavus, knock knee and bowleg

The function of the foot is to supply an organ of locomotion that is springy in order to avoid jars to the brain, spinal cord and abdominal organs Anything that interferes with that function affects the whole body The harmful effects of foot disturbances are manifested in the foot, leg knee, back hip the nerves and the general health.

The causes underlying foot disturbances are concerned with several factors viz., heredity occupation injury, infection hard floors, cement sidewalks asphalt streets shoes, hosiery, the automobile and other present-day living conditions

FOOT DISTURBANCES

Abnormal foot conditions comprise four groups (1) congenital deformities (2) acquired deformities (3) diseases of the bones and joints and (4) tumors

Congenital defects of the feet—deformities that are present at birth—include absence of toes supernumerary toes, united toes, overgrowth of the foot or parts of the foot and overlapping and under riding toes.

Acquired deformities are due to infantile paralysis or other infections, to flatfoot to depression of the fore part of the foot or metatarsal region and to bunions Traumatic conditions are due to fracture

and dislocation Warts papillomas hard and soft corns and circulatory disturbances are acquired conditions

Diseases of the foot are chiefly tuberculosis syphilis osteomyelitis and epiphysitis or inflammation of the growth-center of the bone Arthritis or rheumatism may be due to any germ, to metabolic disturbances or to injury

Posture and Hygiene of the Feet.—SELECTING THE CORRECT SHOES.—The subject of shoes is very important The first question to be considered is whether shoes should be high or low-cut. Both have eminent advocates but to my mind the preponderating evidence is in favor of high shoes Lace-shoes are, as a rule preferable to button-shoes

There has been much discussion in regard to the flexibility or rigidity of the shank of the shoe Individuals without foot troubles may do very well in flexible-shank shoes Those who have foot troubles correctable by exercise only will do well in flexible-shank shoes but for that large number who need both exercise and support the rigid shank shoe is at least temporarily of much greater value. The shoe should have a round toe. It should have a medium width shank. It should be made over a last with a straight inner border The height of the heel should be within reasonable limits as both extremes are undesirable not only because of the effect upon the feet but especially because of the effect upon the back. Shoe fitting is an art too little known. Every individual should change shoes once every day if possible Shoe-trees or shoe-forms are valuable. Rubber heels as a rule, are of distinct advantage in minimizing the repeated shocks to the feet, legs and spine, and to the abdominal and pelvic organs

GARTERS —Constriction of the leg is harmful to the circulation This is true whether the constriction be caused by a circular garter or by rolling stockings in a hard ridge or knot At the beaches one sees many young girls and women with deep ridges just above the knees caused by circular garters This causes interference with the return circulation of the blood and produces varicose veins

Bathing the Feet.—Cleanliness of the feet is of the greatest importance Ordinary bathing of the feet should be carried out once daily The soap used should be of a nonirritating variety and the foot, after being dried should be dusted with a simple dusting powder For "tired feet" the addition of small quantities of salicylic and boric acids to the water may be helpful

Contrast sprays for the feet and legs are administered by sitting on the side of the bathtub and spraying the feet and legs with warm water for one minute and cool water for one minute Alternate in this manner for ten minutes twice daily Increase the contrast of the water gradually from day to day Many prefer to use the warm spray for two minutes and the cool for half a minute

Contrast baths, although not so convenient are of distinct value in improving the circulation of the soft tissues of the foot and leg. To take a contrast bath obtain two buckets, each large enough to contain both feet Fill one bucket about two-thirds full of warm water and the other about two-thirds full of cool water Sit alongside of the buckets. Place both feet in the warm water for exactly one minute. Remove feet and place in the cool water for exactly one minute. Alternate in this manner for ten minutes, i e., five minutes in each bucket. Increase the contrast of the water gradually from day to day If the cool applications are unpleasant reduce their time to 15 to 30 seconds.

Massage.—Massage of the feet twice daily, spending a few minutes every morning and night, is an excellent tonic. In this massage it is well to use cold cream cocoa butter, olive oil, oil of wintergreen or an analgesic ointment such as the following

℞	Olei gaultheriae	4
	Acidi salicylici	4
	Mentholis	4
	Camphorae	4
	Phenolis	1
	Ung. aquae rosae	15
	Lanolin	15

M et ft. ung. and put in collapsible tube or jar
Sig. Use externally for 10 min. twice daily

Do not rub the skin, but use a deep rotatory movement of the thumbs and fingers

Hot Applications.—Hot applications, consisting of flannel dressings wrung out of a hot saturated solution of magnesium sulphate are of value in relieving the ordinary painful foot.

Foot Exercise.—For the young girl's foot there is no exercise of greater value than ordinary ballet dancing if properly taught. It is good for the feet and for the entire body in developing balance, poise and general muscle tone but careless methods on the part of the student and teacher may cause arches to break down instead of becoming stronger Toe-dancing should not be begun as a rule, before the age of ten years Ballroom dancing is excellent exercise but if overdone may produce symptoms of metatarsalgia, i.e., pain in the metatarsal or anterior arch of the foot. Ice-skating and roller-skating are ideal exercises for the feet and legs While skating on ice, a wide figure-eight webbing or leather strap should be worn over the stocking if necessary the ankles may be bandaged or a skate-strap may be worn outside the shoe making a figure eight.

For the abnormal foot with weakness of the supporting structures of the longitudinal and transverse arches a great many special exercises have been prepared. They will be described later

BUNIONS

When the bursa of the big toe joint is inflamed it is called a bunion and corresponds with housemaids knee. *Hallux valgus* is the term applied to the outward deviation of the big toe When a bunion occurs in the region of the fifth toe it is called a 'bunionette There are other conditions of importance in the region of the big toe viz rigid big toe joint rheumatic or gouty joint and sesamoiditis or inflammation of one or both small bones under the joint.

HAMMER TOES

Hammer toes are deformities that are inherited or acquired Such a toe is often the site of a corn. Overriding and underriding toes may often be trained to grow into normal position by simple adhesive strapping Occasionally a toe is so long or so deformed that a surgeon should be consulted as to the proper measure to be taken regarding it.

PAINFUL HEELS

Pain in the heel may be due to a bony spur on its under surface or back or to bursitis or chilblains in this region Very often in the two latter cases it is necessary to remove the counter of the shoe, but frequently elevation of the heel in the shoe will afford relief

For ordinary infections of the foot—as a temporary measure—a hot saturated Epsom-salt solution applied continuously in the form of wet applications with considerable elevation of the foot, will be of much value.

Concerning the care of the feet at various periods of life, I wish to say

1 *The infant's foot* If there is no deformity care of the infant s foot consists of bathing and the application of a dusting powder If there is a clubfoot do not wait until the child is a year old but have treatment started immediately even during the first day of life

2 *The young child's foot* It is important that the baby's stockings and shoes fit properly Fat babies should not be encouraged to stand too early as there is danger of causing bowlegs or knock knees Stiff ankle shoes that is shoes reenforced with molded leather are of value in some cases of weak feet Babies should wear white stockings but care should be taken to prevent the shrinking of the stockings from frequent washing as too tight a sock causes foot-compression and produces injurious results

3 *Care of the feet of the adolescent boy or girl* From infancy to maturity proper and abundant exercise of the foot muscles especially those of the arches is of the highest importance. One should not wait till the arch is weak but should aim to strengthen it early and to keep it strong. In buying shoes for adolescents especially when their feet

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because it provides a point of attachment for the Achilles tendon and furnishes the initial bearing surface of the foot as it strikes the ground in walking

When a foot is in action it is supported chiefly by muscles but when standing chiefly by ligaments.

Foot Posture.—Normally a plumb line dropped from the middle of the kneecap falls through the middle of the tibia the middle of the ankle joint and a point between the roots of the first and second toes If a plumb line is dropped from the middle of the back of the knee, it should be parallel with and bisect the heel tendon

Footprints may reveal a high or a low arch, but they are not of as much practical value as is often supposed

Fig. 17.—Showing what occurs in case of a depressed arch

Fig. 8.—Bones f the foot (top view) in normal nd flatfoot positions.

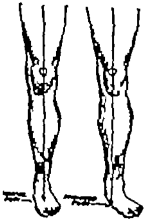


Fig. 9.—Plumb-line test f flatfoot

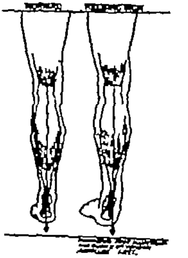


Fig. 10.—Curve f Achilles tendon in flatfoot.

are growing very rapidly or when the feet are unusually long and narrow care should be taken to see that they are fitted properly

4 *The adult* In the care of the adult foot, exercises massage and contrast baths are important. Here proper fitting is necessary The fluoroscope which is in fairly common use at present is of great value in obtaining proper fitting shoes The most important measurement is from the tip of the heel to the middle of the big-toe joint.

5 *The foot of a pregnant woman* must at all times be properly supported because during this period there is a tendency to a relaxation of the supporting structures due, first to the altered metabolism and secondly, to the increased weight her feet are required to carry She must not go around the house barefoot or in bedroom slippers. Her feet should be exercised and massaged twice daily

6 *In old age* frequent elevation of the feet and legs is a valuable aid to the circulation of the lower extremities. This treatment is useful for any one past middle life It may be followed to advantage for an hour every morning and afternoon.

7 *During and after an infection* such as tonsillitis, influenza, scarlet fever and the like, bedroom slippers should be avoided great care must be taken to prevent the relaxation of the supporting structures of the foot due to the toxemia or poison resulting from the infection.

Under the term "occupational foot conditions" we have the foot troubles of the dentist, policeman iceman, barber, waitress, nurse, orderly chauffeur dancer and soldier The peculiar circumstances that cause these disturbances cannot be enlarged upon here but their treatment comes under the general rules laid down in this chapter

Standing causes more strain on the arches than walking because it furnishes no interval of relief from weight-bearing. Many persons can walk miles without tiring but suffer considerably if compelled to stand in a street car or elevated train for thirty minutes.

Physiology of the Foot.—The physiology of the foot consists chiefly of the mechanics of a member whose function is twofold first weight-bearing and second flexible locomotion.

Normally a plumb line dropped from the middle of the kneecap falls through the middle of the mortise-bone of the ankle and through a point between the bases of the first and second toes. This is known as the weight-bearing line. In a normal foot, a line drawn through the middle of the great toe and continued backward passes through a central point in the heel

Two bones of great importance are the astragalus and os calcis The former is important because it is the mortise-bone between the leg and the foot. The astragalus articulates with the tibia fibula, scaphoid and with the os calcis in three places it cannot move itself because it has no muscle attachments it is subjected to more superincumbent weight than any other bone in the body The os calcis is important

the inner surface (the tibials) are stretched and lose some of their power It is a physiologic law that when a normal tendon is over stretched it loses power and when allowed to contract, it promptly does so thereby usually gaining in strength There is gaping of the

FIG. 11.—High degree of pronation or flat feet. Note large exostoses of the first metatarsal heads with bunions and hallux valgus.

bones on the inner border of the foot and compression of the bones on the outer border

Careful examination often reveals that the general muscular condition of a child suffering from flatfoot is below par there may be a generalized muscle weakness Knock knees are more common than bowlegs A round back is frequently present. The mother says the child is awkward that it does not walk properly and that the ankle bones protrude. There seems to be a bone displaced the ankles 'interfere and the child complains of early fatigue has "weak ankles" and runs the shoes over unnaturally The child does not want to run

FLATFOOT

The subject of flatfoot can be discussed under flatfoot in children, in infants and in adults The early treatment is very important and it includes rest, support supination exercises, massage contrast sprays, modification of the shoes and inserts in the shoes Many operations have been devised for the correction of flatfoot, including those of Perthes Gleich Lord Miller Clark and Hoke.

The subject of flatfoot among infants and children is becoming more and more important. The defect has not been given proper consideration Heredity is undoubtedly a very important factor in causing this malformation and in my experience the paternal parent is usually the one involved The various periods at which feet should be inspected are at birth, six months one year two years three years, four years and adolescence Naturally one would anticipate more anatomic deviation of this kind in the negro but it does not appear that the disability or discomfort is more common in that race. Certain disturbances in intra-uterine life might explain some cases for instance unusual foot-position of the embryo might cause it. Any condition causing weakened musculature may produce flatfoot. I have had cases following diphtheria.

There is a definite type of weak pronated or flatfoot that appears coincident with adolescence in long slender, rapidly growing feet, especially in girls Focal infection such as tonsillitis may cause flat foot by a toxic relaxation of the supporting structures unprotected by proper prophylactic measures. These infections might cause a toxic arthritis or rheumatism with resulting rigid flatfoot deformity Such cases are quite resistant to treatment

Obesity causes flatfoot in two ways first by the strain of an excessive load, as there is usually a disproportion between the weight to be carried and the size and power of the feet and lower legs second, by glandular disturbances such as are most likely to be seen in over weight boys and girls Knock knees are often found in these children.

Injury may result in a flatfoot. Infantile paralysis is a frequent cause There may be severe mechanical effects on muscles, ligaments and capsules of the joints and bones.

Anatomic Considerations of Flatfoot.—One of the mechanical changes in flat feet is found to be the inward and downward rotation of the upper border of the heel bone Another is the lateral attachment of the heel tendon This may be the cause or the effect of the mechanical disturbance

The upper border of the mortise-bone is tilted medially carrying the inner border lower than the outer so that the weight strikes a glancing instead of a square blow Mechanically this is injurious. The peroneal tendons on the outer surface of the leg and ankle contract. Those on

correct other conditions such as knock knees or bowlegs The means to these ends include proper shoes exercises massage contrast foot baths resilient pads, plaster-of-paris casts and operation.

The child should be taught to walk with the feet parallel or toeing-in slightly It should come down on its heels, tilt its weight to the outer borders of the feet and come up on the toes with a spring

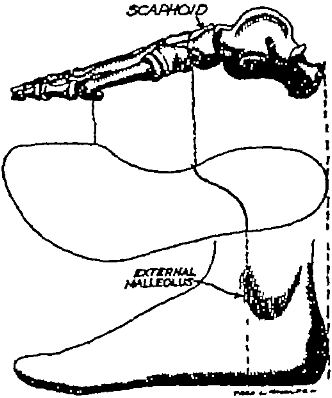


Fig. 15.—Illustrating inner and outer border measurements of H. O Thomas orthopedic heel.

Shoes.—Only in extreme cases will it be necessary to have the shoe made to order but it should be a well fitted lace-shoe. The writer always recommends shoes that come up around the ankle but many good orthopedic surgeons recommend low shoes as giving more free dom to the ankles Some authorities permit low shoes for healthy or only slightly weakened feet The most important measurement is from the back of the heel to the middle of the big toe joint which should be opposite the point at which the shank joins the ball of the sole Next the shoe must grasp the heel of the wearer It must not be too wide at the heel and through the shank and should allow for the growth of the foot. The use of a fluoroscope in fitting shoes is of great value.

Flexible-shank shoes are indicated when the patient needs only exercise but most of the patients brought to the orthopedic surgeon

and play Pain is usually absent because the foot is flexible but if rheumatism should develop, decreasing flexibility, a rigid flatfoot would result in a disabling deformity

On viewing the child from the front, one sees the flattening of the arch and the outward deviation of the fore part of the foot. A plumb line dropped from the middle of the patella falls inside the normal point. A rear view reveals the medialward curving of the heel tendon. A plumb line dropped from the middle of the popliteal space is not parallel with the heel tendon The heel is flattened and rotated in some cases producing the "heel of the ape." The prominence of the region just below and in front of the inner ankle bone (the scaphoid) resem-

FIG 11.—A and B Incorrect standing posture; C, correct posture.

bles another ankle bone It is possible to have a flatfoot on one side and a clubfoot on the other

The value of footprints has been overestimated from the viewpoint both of diagnosis and of progress The print of the new born infant is misleading in that it usually looks flat As a matter of fact, the foot of a new-born infant if cross-sectioned will reveal a definite bony arch obliterated by a fat pad. One may find a foot with a high arch but in a position of strain

The chances of recovering from flatfoot are very good depending on how well the patient parent or governess carries out the treatment In the rigid type the duration of treatment may be long

Treatment.—The objectives of treatment are to teach proper walking to increase the power of the supporting structures to stimulate the local circulation to correct the flattening and restore the arch and to

quite satisfactory for preliminary wear. It may be discontinued when the feet improve in strength.

The modification of the shoe consists chiefly in the application of a Thomas heel, a method devised many years ago by an orthopedic surgeon of Liverpool, and one that has been altered at times but never improved. Each child must be measured for this heel. There are four

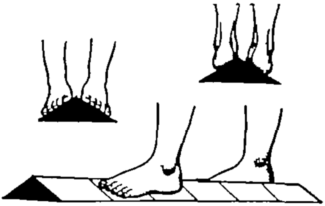


Fig. 17.—Supination board. Above, front and rear views. Below, side view.

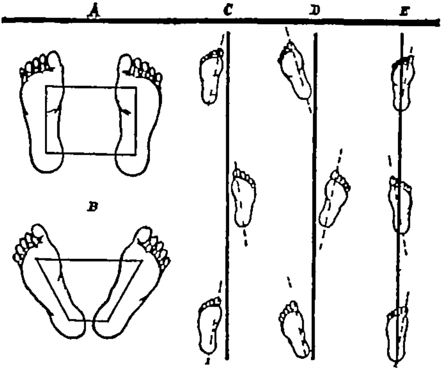
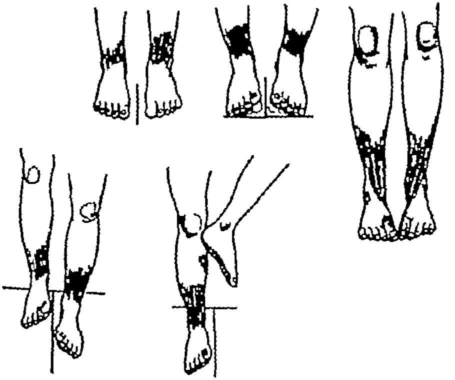
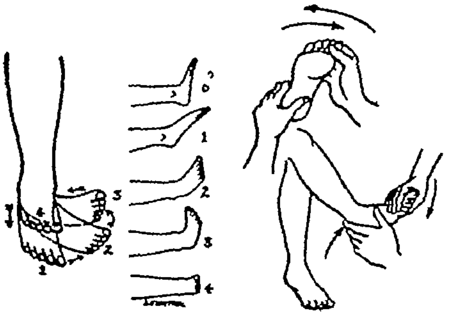


Fig. 18.—Right and wrong foot postures. A, correct standing position. B, military standing position—incorrect. C, correct walking position. D, military walking position—incorrect. E, Indian position, walking. (Ellis.)

need both exercise and support, and the latter need is not supplied except by a rigid or semirigid shank The problem is like that of keeping a bridge from sagging in the middle. The insertion of a corrugated metal shank changes a flexible-shank shoe into one that is





Figs. 24, 25, 26.—Longitudinal arch exercises.

dimensions the inner border height the outer border height, the inner border length and the outer border length The imitations so frequently seen of this heel are very poor The function of the heel is to compel the child to walk over the outer border of the foot and when properly made it forces his ankle into the correct position Re enforced uppers for "weak ankles" are used occasionally as a tem porary measure. It is important that the leather reenforcement be carefully molded over the ankle bones or pressure-areas will result.

Gymnasium shoes should be worn for gymnasium use only They should include the ankle and have resilient pads inserted Ballet slippers should not be worn except while dancing They too can be padded

The child must not go barefoot except in the sand or in soft ground During convalescence from any illness it is very important that the child s feet be supported at all times during weight bearing, because it is a period of relaxation of the supporting structures of the arch One should never permit bedroom slippers to be worn.

Exercises to Correct Flatfoot —Exercises are the most im portant factor in the treatment They are active and resistive and should be carried out twice daily in bare or in stockinged feet. Exer cises must be done slowly and the feet should never be allowed to come down with a bang" A great many special exercises have been described Some of the most valuable are these

1 Stand barefoot with the feet parallel and about two inches apart straddling a seam or a line in a rug On the count of 1 force the feet apart without actually allowing them to move apart thus throwing the weight on their outer borders on the count of 2 allow them to roll in slowly but not all the way This is repeated ten times at first with a gradual daily increase that may run up to 100

2 Same as number 1 except that the two big toes are held together and on the floor

3 Straddling a seam in the rug or a line on the floor walk across the room with all the weight on the outer borders of the feet and the toes curled downward and inward Make the round trip five times.

4 This is the same as number 3 except that one raises one foot so that it is opposite the other knee and walks across the room in that way using the so-called ostrich-step' Weight must at all times be borne on the outer border of the foot.

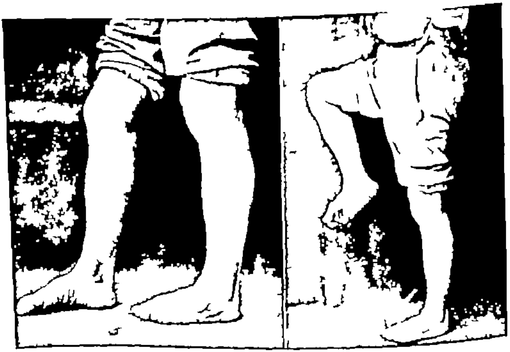
5 The feet are held parallel and the knees are maintained in a straight position The knees are then rolled outward which automatically causes the longitudinal arches to rise (Lowman) This is re peated from 10 to 25 times

6 Rise on the toes tilt the weight to the outer borders and come down in two counts This should be done from 10 to 25 times

7 Use a supination board about six inches high and eight feet long its sloping sides being at the angle of an isosceles triangle The child

A B C

FIG. 29.—Illustrating standing exercises for flat feet. A, exercise No. 1; B, exercise No. 2 as seen from the front. C, exercise No. 2 as seen from the rear.



A B

FIG. 30.—Illustrating walking exercises for flat feet. A, exercise No. 3. B, exercise No. 4.

10 Older children and adults can perform this exercise as follows The left foot is turned inward and upward and held in that position firmly The right foot is placed against the left and attempts to force the left outward which effort the left foot resists Then the relation of feet to each other is reversed After each of these exercises the subject relaxes his feet

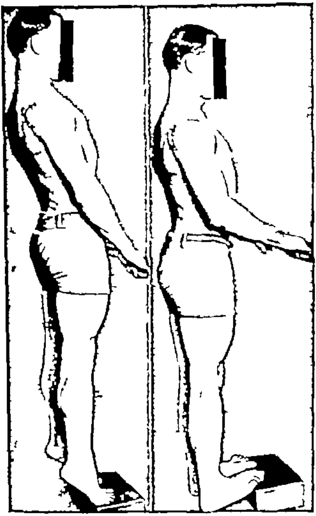


Fig. 32—Exercise for stretching the Achilles tendons. (Lewin, J.A.M.A., 88, April 9, 1927)

Stretching the Heel Tendon—The following are a few special exercises for stretching the Achilles tendon

1 Simply walking on the heels across the room five times

2 From the standing position with the feet parallel the patient squats down to the position of sitting on the heels maintaining the heels and toes on the ground This is done in two counts.

walks the length of the board three or four times as one would walk on the ridge of a housetop

8 The subject is seated on a chair with legs crossed, so that the raised foot can relax He then holds the foot at right angles with the leg and not turned in or out The exercise is done in four counts. On the count of 1 the foot is allowed to relax into the position of toe drop On the count of 2 it is swung in on the count of 3 it is

FIG. 31 —Exercise No. 10 for flat feet

forcibly pulled upward and on the count of 4 it is brought back to the starting position describing a half-circle. This is performed 10 times at first and may gradually be increased to 25 times.

9 This is a resistive exercise The subject sits on a table, and a second person sits on a chair The subject forcibly swings his foot inward and upward and holds it in this position with all his power The second person attempts to swing the foot outward and downward This effort on the part of the second person is resisted by the subject. The exercise is carried out from 10 to 25 times. At no time should the second person use as much power as the first.

in the foot therefore very little space is required They are inserted directly into the shoes and held by means of a special glue

A Goldthwait figure-of-eight leather ankle strap is of some value Adhesive strapping is often beneficial especially for injured feet Plaster of paris is necessary in some cases and is usually better than braces for short periods Some orthopedic surgeons recommend plaster over comparatively long periods in an attempt to cause a certain degree of rigidity or stiffness in an overcorrected position. Braces may be required

Operation is rarely indicated except for rigid flat feet, in which type forcible manipulation under anesthesia and the application of a corrective plaster cast are of great value Occasionally the tendons must be operated upon. Lengthening of the heel tendon is necessary in so-called "muscle-bound feet, because patients suffering from this condition are unable to perform the exercises properly owing to the structural shortening of the tendon

Other operations are those performed on the bones and tendons

DISTURBANCES OF THE METATARSAL ARCH

The subject of metatarsal-arch disturbances—popularly known as one type of fallen arches"—is attaining the increasing importance it deserves. For a long period it was a general conception that nearly every condition occurring in this region was a Morton s toe The term *metatarsalgia* meaning pain in this region designates a symptom and does not fully describe the condition

The metatarsophalangeal joints are simple ball and-socket joints Like other joints therefore they are subject to stress strain injury growth disturbance and infection The muscles and tendons of this region are important.

The skin of the plantar surface of this area is unusually thick. The chief functions of the metatarsal regions are to afford stability in locomotion to permit spring and resilience to the step and to relieve jars on the body especially on the spine and the central nervous system The transverse arch is highest near the midportion of the foot and gradually lowers toward the metatarsal heads Considered from the mechanical point of view the metatarsal arch is curved in two directions laterally and from front to back. What is usually referred to as the metatarsal arch is that structure formed by the metatarsal heads and is the true transverse arch This mechanical structure protects the nerves vessels muscles tendons and ligaments of the sole of the foot from injury

The transverse arch is maintained chiefly by the transversely directed ligaments When the transverse arch is properly maintained the anterior pillar of the longitudinal arch rests on the heads of the first and fourth metatarsal bones only that of the fifth also presses on the ground in many cases especially when more weight is borne on

3 The patient stands facing the wall with the toes 28 inches from it The toes are placed together and the heels as far apart as possible. With the hands placed against the wall and the heels remaining on the floor, the entire rigid body is allowed to fall forward as far as possible by bending the elbows, and to remain in this position a few seconds before returning to the starting position This is done in two counts, each about ten times

4 The apparatus for this exercise consists of two handles fastened to the wall and a heavy wooden block 3½ inches high, 12 inches wide and 7 inches in depth, fastened to the floor The patient faces the wall, standing with the anterior portions of both feet on the block and holding on to the handles On the count of 1, the heels are allowed to touch the floor the body being kept parallel with the wall On the count of 2, the return is made to the starting position The exercise is carried out from 10 to 20 times, this number being attained gradually

5 The patient stands with the anterior half of each foot on a stair facing upward and holding the balustrade, and allows the heels to drop He then returns to the starting position

Other Exercises —Ballet dancing is excellent exercise because of the foot training although much of it is very hard on the longitudinal arch at first There are, indeed, some children for whom it is detrimental until their feet have been strengthened by the treatment outlined here Ballet dancing may be started at the age of 4 or 5 years, toe-dancing should not be started, as a rule, before the age of 8 or 10 years.

Swimming is very good exercise Roller-skating also is good and so is ice-skating but both may be harmful at first unless proper precautions are taken. The child should wear a wide figure-of-eight webbing or leather strap outside of the shoe Kiddy-cars may be injurious under certain circumstances

Massage of the feet and legs should be given twice daily using olive oil or cocoa butter The movement should be deep and rotatory In the case of painful feet in older children an anodyne ointment should be used. Contrast foot bathing should be prescribed for older children

Support for the longitudinal arch is obtained by means of felt or rubber pads. These afford a resilient support and thereby increase the spring of the gait. They are preferable to rigid supports such as those made of metal celluloid or leather Metal arch-supports prevent the supporting structures from growing stronger

I have long since discontinued the use of leather insoles, because they confuse the shoe fitter who cannot judge accurately the amount of space to be allowed. He should be instructed to fit the foot accurately without allowing for anything. The pads go into natural hollows

proper shoes and incorrect shoe-fitting Short stockings and the pulling of stockings too tightly are additional factors Heredity may be im portant, especially in the rheumatic and 'high instep pes cavus cases.

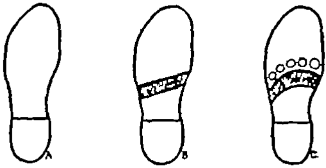


FIG 35 —Modification of shoe for correction of anterio arch depression. A sole of a proper walking-shoe B position of leather metatarsal bar ½ inch thick and 1 inch wide. C, position of metatarsal crescent and relation to heads f metatarsals.

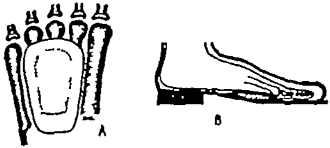


FIG. 36 —Using a felt pad for a depressed metatarsal arch A, position of beveled pad with relation to metatarsal rch. B position of pad in shoe.

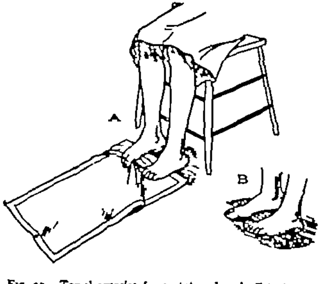


FIG. 37 —Towel exercise f r metatarsal arch disturbance.

the foot. If the transverse arch yields, the heads of the intervening metatarsal bones receive undue pressure and callosities develop under them When the muscles of this region are paralyzed or weakened, the toes assume a position of "clawtoe and the normal gait is interfered with Conversely, if the toes are forced to assume a position of

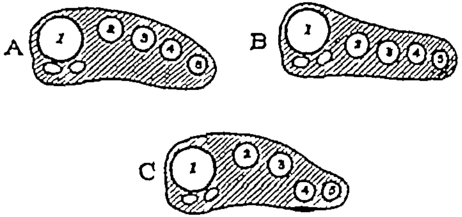


FIG. 33.—A, normal position of metatarsal heads and sesamoid bones. B, depressed metatarsal arch C depression of fourth metatarsal head, with production of callosity

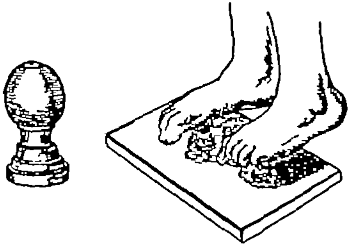


FIG. 34.—Door-stop exercise for metatarsal arch weakness.

clawing by any agent, such as improper shoes these two groups of muscles are unable to function properly and the unopposed action of other muscles aggravates the clawing and forces the metatarsal heads to assume a depressed position

Causes of Depressed Metatarsal Arch.—Metatarsal disturbances are due to various causes Comparatively infrequent in childhood they are very common in adults. Women suffer from them more often than men undoubtedly because they are so frequently the victims of im-

cation of an anodyne lotion is used in conjunction with hot applications and elevation of the feet.

Shoes must be of straight last, round toe medium-width shank and moderate-height heel. The shank should be rigid if there is an accompanying disturbance of the longitudinal arch. The fitting of the shoe is very important. Even custom made shoes are often too short. The shoe may be modified by the addition or insertion of a metatarsal bar

FIG. 38.—Metatarsal elastic band.

or preferably a crescent. Into the shoe there should be inserted a felt pad properly shaped and beveled to support the depressed structures This pad may be applied directly to the foot temporarily secured by means of a resinous glue and strips of adhesive plaster or by means of a simple elastic metatarsal cuff which in itself has some value in supporting the arch laterally A laced leather cuff is preferred by some orthopedic surgeons An adhesive compression band often affords considerable temporary relief

The felt pad is usually inserted directly into the shoe, being secured by means of glue. An insole is not essential Because it is not physio-

Rheumatism is an important cause of metatarsalgia. Infections of various types contribute a fair share of these cases. The infection may be local or focal, such as infected teeth, tonsils, sinuses and abdominal or pelvic organs. Toxemia as from pregnancy or from an infection such as influenza, is a causative factor Static disturbances, such as prolonged standing on hard floors predispose to arch troubles. Injuries of various sorts are very important such as the sprain or strain seen in the chauffeur s foot or in the dancer's foot, especially in toe-dancing The injury from shoes has been mentioned. Injury by falling objects or being stepped on by another person or by an animal may cause metatarsalgia I have seen a nurse who developed metatarsalgia following the accidental shooting off of all her toes. I have also seen a physician who had metatarsalgia following a septic infection of the metatarsal region as a result of the piercing of his shoe by an infected knife which dropped during an operation. Fractures dislocations and burns both by heat and by chemicals may result in metatarsalgia the same is true of a "high instep,' sometimes appearing at puberty disturbances of the circulation, frost-bite, chilblains trench foot, and soft corns

There is depression or inversion of the arch, which normally is convex above This produces pressure on the nerves and relaxation of the supporting structures Warts and soft corns (usually between the fourth and fifth toes) are common

Symptoms.—The symptoms of metatarsal arch disturbances are pain rigidity and at times, spasm of the muscles and contracture of their tendons The physical conditions of metatarsal depression are the inversion of the arch callus formation, sensitiveness and tenderness, usually due to periostitis Every schoolboy knows that if he can grasp another boy s hand depress the knuckles and exert lateral compression he can cause pain. An analogous situation is found in a depressed metatarsal arch

Roentgenograms are usually not necessary in making a diagnosis, although they are always desirable They reveal the depression on side view and also show bunions "bunionettes (overgrowth of the fifth metatarsal heads) and the position and integrity of the two sesamoids under the big toe joint.

Methods of Treatment.—The result of treatment depends on the coöperation of the patient. The course is often long The treatment of the usual type of metatarsalgia consists of local and general measures, the latter being removal of foci of infection and the correction of metabolic hygienic and dietetic disturbances The local treatment consists of relief from inflammation or irritation, proper shoes and shoeing metatarsal support and the physiologic restoration of power of the supporting structures of the arch

Relief from inflammation may be accomplished by rest and relief from weight bearing. In the severe cases rest in bed with the appli-

they are screwed into a board about 14 inches long 8 inches wide and 2 inches thick. The centers of the door stops should be 6 inches apart.

The board is placed on the floor and the patient sits on a chair in front of it. Each foot is placed on a door-stop with very slight pressure *just behind* the metatarsal bones On the count of 1 the toes are forcibly curled down and on the count of 2 they are allowed to relax slowly This is continued until one has counted 200 (This number should be attained gradually)

Towel Exercise —The patient sits in a chair A large hand-towel is spread on the carpet with the narrow edge facing the patient. Both feet are placed on the towel so that half of each foot is on the towel The towel is grasped with the toes of one foot then with the toes of the other As the toes of one foot grasp those of the other foot relax. This is continued until the entire towel is under the feet.

Golf-ball Exercise —A golf-ball is placed on the rug and rolled under the metatarsal arch for one minute Then it is picked up with the toes of one foot and placed under the toes of the other foot, and the exercise is repeated for another minute The patient alternates in this manner six times

Marble Exercise —Marbles of various sizes are placed on a rug. The patient sits in a chair and picks up marbles with her toes

Pencil Exercise —A round pencil is placed on a hard floor and by means of the curled down toes the patient pushes and pulls the pencil around the floor with short, quick movements

ARCH-SUPPORTS —There has been much discussion concerning metal arch-supports. It is the writer s belief based on some years experience, that metal arch-supports because they act as props or crutches are of doubtful value While they brace or hold up an arch, they do not increase the power of the supporting structures of the arch in fact the effect produced is generally one of weakening and they are therefore not recommended Arches can be held up by resilient material which not only supports but tends to increase the strength of the supporting structures of the feet.

Diathermy negative galvanism and sinusoidal current are helpful adjuvants in the treatment of metatarsalgia Plaster-of-paris casts are frequently required Less frequently is operation necessary

Among the allied conditions found are profuse perspiration, ring worm hard and soft corns calluses warts bunions "bunionettes" hammer toes contracted tendons circulatory disturbances and a stiff big toe

ANKLE SPRAINS

A sprain is a stretching or tearing of the muscles tendons ligaments or capsule of the joint A fracture is a break of a bone There is a saying that a sprain is worse than a broken bone This is untrue. Many sprains however are improperly treated because the roentgen

logically correct to compress the delicate foot muscles between the rigid bones above and a rigid object below, I practically never use a metal plate to support a depressed metatarsal arch, depending entirely on the resilient support of the felt pad The patient's hose should be long enough and must not be drawn too tightly Massage of the feet twice daily with a special ointment is very valuable. Contrast foot baths afford the feet a very valuable tonic

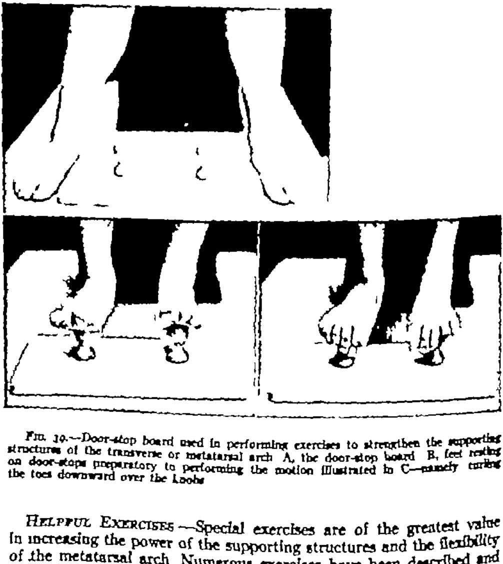


FIG. 10.—Door-stop board used in performing exercises to strengthen the supporting structures of the transverse or metatarsal arch A, the door-stop board B, feet resting on door-stops preparatory to performing the motion illustrated in C—namely curling the toes downward over the knobs

HELPFUL EXERCISES—Special exercises are of the greatest value in increasing the power of the supporting structures and the flexibility of the metatarsal arch Numerous exercises have been described and recommended The following have been found of much value. Each exercise is done with the bare feet twice daily

Door stop Exercise—Two old-fashioned door-stops, obtainable at the hardware section of one of the 5 and 10-cent stores are prepared for use by removal of the rubber tips with a pair of nippers. Then

There is still a divergence of opinion concerning the immediate treatment of a sprained ankle. The following is a good routine

1 Give it absolute freedom from bearing weight
2 Elevate the entire limb
3 Apply a snug gauze bandage over sheet wadding or cotton
4 Apply ice bags
5 Have a roentgenogram made and strap the ankle with adhesive or if the sprain is severe apply a plaster-of paris cast.

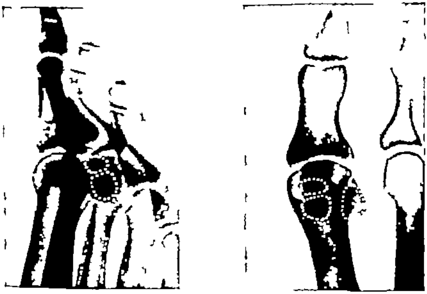


Fig. 41 —Split sesamoid bone, producing pain under big-toe joint

Fig. 42 —Proper shoe f r lady after bunion operation.

ogram does not reveal a fracture or dislocation, the condition may then become serious from lack of sufficient attention Oftentimes the best treatment for a sprain is the application of a plaster-of-paris cast for a few days combined with the elevation of the foot and leg then the application of a firm adhesive strapping After seven to fourteen

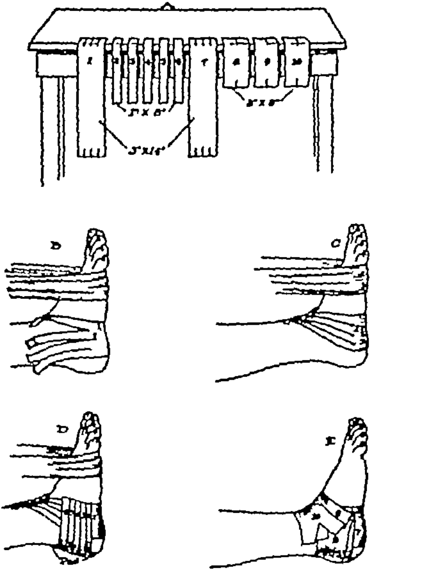


FIG. 40.—Adhesive strapping for sprained ankle.

days an elastic anglet or resilient bandage is worn This is removed morning and evening for massage and contrast baths If diathermy or radiant heat can be given it will hasten recovery Passive movements of the joints by a second person and active movements but no weight bearing by the patient are very important and should be carried out within the limit of pain.

FIG. 43A.—Third and fourth, or last, stages of ankle strapping.

FIG. 44.—Ankle and leg strapping to protect the Achilles tendon and support the calf

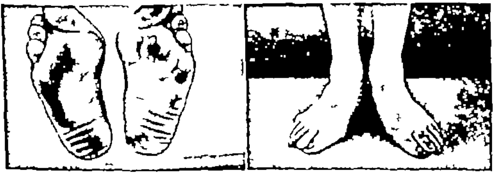


FIG. 45.—Bunions, hallux valgus and flat feet

FIG. 43—Lewin's method of adhesive strapping of ankle. 1 Adhesive cut in strips and cut as described in text 2 Holding foot in proper position by means of bandage guy ropes. 3 Application of preliminary strips of adhesive. 4. Strapping half completed.

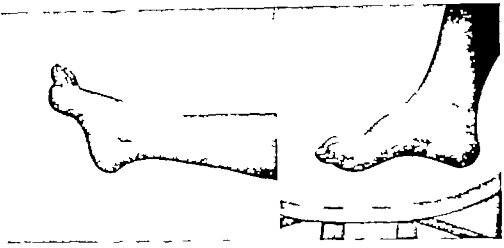


FIG. 48.—Pes cavus, o hollow foot. Note the high longitudinal and low transverse arches.

and determine the amount of blood going to the tissues They are not under the control of the individual They are affected by such poisons as alcohol, tobacco lead arsenic and infections

RIGID TOE JOINT

Hallux rigidus or rigid big-toe joint, whether of the flexed or the straight variety may be relieved by the insertion of a thin strip of steel the entire length of the sole of the shoe in order to prevent movement at the big toe joint. True gout is not seen very often at present but there is a very definite rheumatic condition occurring in the region of the big-toe joint that is either caused or aggravated by disturbances of metabolism, especially the metabolism of meat fish and eggs Sesamoiditis is a painful condition involving the under surface of the big toe joint The sesamoids in the tendons are subject to much stress and strain especially in stepping or jumping from a height or in dancing. Often the roentgenogram will reveal a division of a sesamoid resembling fracture Many of these are developmental pecu liarities which are especially susceptible to injury Usually relief from weight-bearing affords comfort but occasionally removal of the bone is necessary

HALLUX VALGUS

Bunions are due to bursitis or inflammation of the bursal sac in the region of the big toe joint Hallux valgus is the outward deviation of the big toe with the formation of an overgrowth of bone (exostosis) at the big-toe joint The chief causes are heredity short or pointed shoes short stockings infection or injury The most important prophylactic, or preventive measure is proper shoes and shoe-fitting from infancy to old age

6 Crutches should be used

7 The foot should not hang down for long periods The guides, in this respect, are swelling, blueness and pain

The arteries of the limbs have sympathetic nerves in their walls These nerves control the size of the openings to the smaller vessels

FIG. 46—An extreme case of bunions, hallux valgus, calluses and corns.

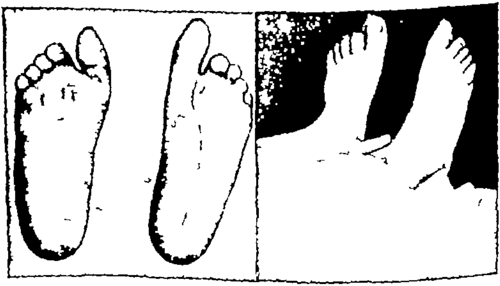


FIG. 47—The same feet as shown in Figure 46 after operation designed by Dr John L. Porter [Porter Surg. Gynec Obst., 26 460 (April) 1918.]

HOLLOW FOOT

Pes cavus or hollow foot, is an exaggeration of the longitudinal arch with depression of the metatarsal arch. There is usually limitation of dorsiflexion.

Heredity is an important factor I have seen three members of one family with this deformity High-heel shoes excessive use of the calf muscles (sometimes seen in dancers) infantile paralysis neuritis in childhood gout, rheumatism injury and habitual posture of the foot such as is seen in compensation for a short limb are other factors in causing this condition

CALCANEAL SPURS

Etiology —It is the customary teaching that all calcaneal spurs are gonorrheal in origin This is grossly wrong The various factors are as follows First, focal infections with the ordinary cocci, gonococci and spirochetes second metabolic disturbances, especially of gastro-intestinal and gallbladder origin (I have seen a large number of cases in which the metabolic factor either was most important or was an element in the exaggeration of other factors possibly in the nature of a sensitization process) third trauma due to injury and improper shoes fourth static, due to flat feet and fifth a pathologic condition of the plantar fascia—a short plantar fascia pulling on its attachment to the os calcis

Anatomy —The plantar fascia takes its origin from the tuberosity of the os calcis If pressure is applied to this area or if the plantar fascia pulls on its attachment there will result a slight separation or pulling off of the periosteum at this point Owing to the stimulation of trauma or infection or both osteogenesis occurs more actively and a vicious cycle is established i e as the periosteum separates new bone formation occurs and a spur results due to the proliferation of the osteogenic layer of the periosteum

Symptoms.—The symptoms are pain tenderness swelling and limp The onset is usually gradual except when due to an infection such as acute arthritis when it may be very acute. The pain and tenderness are usually along the internal lateral border of the os calcis or at the attachment of the plantar fascia. The roentgenogram may or may not reveal a bony spur depending on the duration of the pathologic condition and the density of the spur Many very painful heels are seen roentgenograms of which reveal no spurs

Diagnosis.—The differential diagnosis rests between osteoma, flat foot and arthritis

Prognosis.—The prognosis of complete relief is good if the spur is the only cause of trouble If there is an arthritis of the foot removal

FIG. 49.—Well-developed calcified spur causing no symptoms.

FIG. 50.—Very slight spur formation of os calcis causing intense pain and sensitiveness in the heel.

It is a fairly common condition, occurring usually in boys between the ages of nine and thirteen years The probable cause is concerned with two factors local injury either external or internal and local circulatory disturbances affecting the growth center during a critical period in its development. The treatment consists of immobilization in plaster of paris and relief from weight-bearing, plus general hygienic considerations The chances of recovery are excellent.

There may be a history of injury but the initial causes differ The child might have been running on hard pavements wearing sandals or tennis shoes. The onset is gradual A limp is usually the first symptom and it may or may not be accompanied by pain The pain is dull and localized to the affected area It is less marked while shoes with heels are worn Pressure by the shoe aggravates the pain. Swelling is present. There may be obliteration of the normal outlines, due to thickening of the tissues Signs of acute infection are not prominent. Tenderness may be present over the posterior portion of the heel for weeks or even months The child does not permit stretching of the heel tendon, which accounts for the toe-drop position of the foot There is a disinclination to complete the full step while walking Flatfoot may be present.

Roentgenograms made in two directions reveal irregularity of the bone with thickening in all directions Clouding irregularity or partial obliteration of the epiphysial space may be observed

Other conditions occurring in this area are

Achillobursitis or inflammation of the bursa between the Achilles tendon and the os calcis reveals a more superficial and localized inflammation Roentgenograms of the bone are normal

Tenosynovitis of the Achilles tendon is characterized by pain referred to the tendon and by palpable grating crepitus or roughness on movement. The roentgenogram is negative

Bursitis between the heel tendon and the skin is a superficial inflammation usually the result of pressure by the shoe

The prognosis in apophysitis of the os calcis is excellent if proper orthopedic treatment is instituted The duration of the condition may vary from a few weeks to several months. The trouble may recur as a result of overactivity or injury

Treatment.—The treatment of apophysitis is simple The objectives are to relieve the Achilles tendon of strain and to prevent weight bearing on the os calcis The most satisfactory treatment of a severe case consists of the application of a plaster-of paris cast extending from the toes to just above the knee in such a manner as to hold the foot in a slight toe drop—thus relaxing the pull of the calf group muscles—and the knee slightly bent Two crutches and a two-inch block under the heel and sole of the opposite shoe aid in locomotion.

of the spur will not give sufficient relief Most patients can be made comfortable without operation others are not relieved by operation. There may be recurrence of symptoms and spur formation in the same or the opposite foot.

Treatment.—NONOPERATIVE.—The etiologic factors the residue of a gonococcus infection, infected tonsils or teeth should be treated if they can be found The gastro-intestinal condition should be relieved if possible Weight bearing should be discontinued and bed treatment, consisting of the application of an anodyne lotion plus fomentations, should be given An excellent anodyne lotion is described on page 7

Directions for the use of this lotion are as follows The entire foot and ankle are covered by four layers of gauze saturated with the lotion and enclosed in oiled silk or rubber sheeting Hot fomentations of strips or pads of flannel are wrung out of hot water about six layers wrapped around the impervious layer, and another sheet of oiled silk applied A hot water bag is placed at the side or under the foot and everything enclosed in a Turkish towel The foot should be elevated. A small amount of lotion is added and the fomentations renewed three times daily

After all pain and most of the sensitiveness have disappeared plaster-of-paris casts should be applied Proper shoes are prescribed after casts have been worn from two to four weeks. Shoes should be high laced of straight last round toe and medium width shank, rigid at first Felt pads are inserted in the shoes to relieve weight-bearing on painful areas The heel of the shoe should be entirely removed and a low rubber heel substituted Roentgenotherapy is advocated by some I had a patient who pounded his heels with the flat side of a hammer daily for many months and experienced relief

OPERATIVE.—Operative treatment consists in the removal of the spur Operative trauma often stimulates osteogenesis especially if the causative agent is still operating The size of the spur is not the determining factor The removal of the spur is accomplished by means of a chisel or osteotome and mallet Plaster casts are applied and should remain in position for about ten days

POSTOPERATIVE.—Postoperative care consists in the relief from weight-bearing by means of proper shoes into which are inserted weight relieving felt pads The diet should be considered very important in cases of metabolic disturbance, and these cases are very common. As a rule meat eggs and fish are contraindicated Diathermy is beneficial for an accompanying arthritis.

APOPHYSITIS OF THE CALCIS

Apophysitis of the os calcis first described by Sever is an inflammation of the cap-like epiphysis of the posterior portion of the heel bone

Upper Arm.—Conditions of the upper arm are chiefly rupture of the biceps tendon posttraumatic such as fractures and dislocations rupture of muscle rupture of tendon myositis and brachial neuritis The chief measures of value are radiant heat massage and diathermy

Elbow —Conditions around the elbow that are benefited by physical therapy are chiefly arthritis periarthritis bursitis posttraumatic conditions such as fracture dislocation fracture-dislocation, epiphysial separation rupture of the attachments of the flexor and extensor tendons The most valuable measures are rest, radiant heat, massage dia

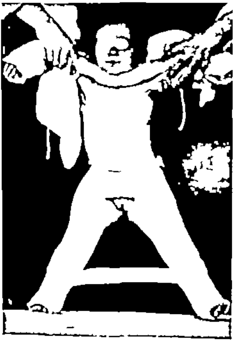


Fig. 5 —Bowlegs (genu varum) in child of 3 years. Multiple osteotomies and double spica cast.

Fig. 5 —Double plaster-of paris spica to maintain correction in a child wh had severe bowlegs which were corrected by multiple closed osteotomies

This case should be removed at the end of two weeks and another immediately applied extending from the toes to the garter line holding the foot at a right angle and not turned inward or outward At the end of four more weeks this cast should be removed and a high, laced shoe with a three-quarter inch cork lift for the heel worn Weight bearing with the aid of crutches should be carried out for another two weeks Contrast baths, baking or diathermy should be employed during this period

During the course of treatment emphasis should be placed upon direct sunlight and proper food If a glandular disturbance is present, proper treatment should be instituted

If the case is so mild that the foregoing treatment is not necessary it will be sufficient to elevate the heel remove the counter of the shoe and insert a pad of felt or sponge rubber in the heel The heel may be protected by adhesive strapping and the flatfoot corrected. Rubber heels should be worn

KNOCK KNEE—BOWLEG

These conditions are caused most commonly by rickets and other nutritional disturbances. Deformity should be prevented if possible if not, it should be corrected The means of correction include massage, ultraviolet lamp modifications of the shoes plaster-of-paris casts, braces and operation

Indications for Physical Therapy in Various Regions

The various regions will be considered in the following outline Shoulder upper arm elbow forearm, wrist hand, hip, thigh, knee leg ankle foot.

Shoulder —The chief conditions around and in the shoulder joint that are benefited by physical therapy are (1) arthritis (2) periarthritis (3) subdeltoid bursitis (4) calcification in and around the supraspinatus tendon (5) brachial birth palsy (6) fractures and dislocations the most important being subdeltoid bursitis and calcification of the supraspinatus tendon arthritis and periarthritis. In arthritis the tendency is for an adduction deformity with resulting contracture of the subscapularis and pectoralis major tendons. By means of physical therapy these can be prevented and if they have occurred, much can be done to correct the deformity

The measures which are most valuable are rest, radiant heat, massage passive and active movements manipulation plaster casts, braces and diathermy

Physical therapy agents are of value after fractures and dislocations of the shoulder One must beware of displacing the fragments in the case of fracture and displacing bones in the case of dislocation producing redislocation

splinting midway between pronation and supination local applications of heat very gentle massage and diathermy Operation is frequently required. After fractures of the elbow in children there is danger of myositis ossificans After dislocations about the elbow physical therapy must be very carefully instituted because of the danger of adhesions and stiffness

In cases of dislocation of the upper end of the radius with rupture of the orbicular ligament suture of this structure may be required using fascia as a plastic means of reconstructing the ligament.

Forearm.—Conditions in the forearm include rupture of muscles or tendons myositis fibrositis paralysis of muscles pronation contracture Volkmann s ischemic contracture posttraumatic such as fractures and synostosis The most valuable physical therapy measures are rest radiant heat, massage diathermy and active and passive movements

Splinting of the forearm wrist and fingers in cases of Volkmann s paralysis is very important if operation is to be prevented.

Wrist.—The conditions at the wrist which are benefited by physical therapy are arthritis fracture dislocation fracture and dislocation epiphysial separation fracture and dislocation of the carpal bones The most important fracture is of the scaphoid the most important dislocation is that of the semilunar After proper reduction or extirpation of the involved structures physical therapy measures are of value and the most important are rest, radiant heat, massage diathermy active and passive movements

Hand.—The important conditions in the hand are contractures of the hand the fingers and thumb arthritis posttraumatic, such as fracture and dislocation ischemic contracture and wristdrop The most valuable measures are radiant heat, massage diathermy manipulation, active and passive movements support such as braces plaster casts and special splints

In case of Dupuytren s contracture many of these can be prevented in the early stages by splints If they cannot be prevented operation is indicated The best operation is that described by Kanavel Koch and Mason

Hip —In the hip the most important conditions are flexion contracture arthritis periarthritis and bursitis

An adduction deformity may require tenotomy of the adductors In a case of trochanter bursitis—that is bursitis in the region of the great trochanter—rest local applications radiant heat and diathermy are indicated

Thigh.—In the thigh the important conditions are myositis fractures bursitis and paralysis

thermy and passive and active movements Braces splints and casts are of value Manipulation under anesthesia is valuable in cases of adhesions

Bursitis in the elbow region There is a condition known as tennis elbow, epicondylitis, or radiohumeral bursitis which is caused by tennis playing and other activities The treatment includes rest,

FIG. 53—Three views of a plaster-of paris spica cast of the shoulder (N external rotation was indicated in this case.) A complete cast as seen from the front B as seen from the rear C, the upper half of the cast has been removed and the arm is taken out of the cast for massage and exercises. The cast as used in this manner is called a shelving cast.

In the thigh rider's muscle is due to irritation and in some cases it is amenable to treatment by rest and very gentle massage. In some cases operation is necessary

Knee.—The important conditions in and about the knee include arthritis, internal derangements external derangements conditions affecting the bones muscles tendons and ligaments fibrositis traumatic synovitis fractures dislocations and bursitis

For the knee conditions one recommends rest, radiant heat massage and diathermy which are usually very effective.

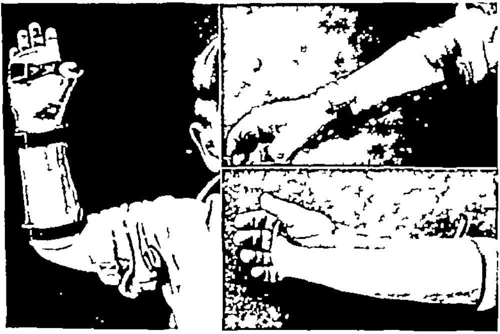


FIG. 57.—Lewin's aluminum forearm and hand splint.

In semilunar cartilage disturbances, the treatment includes manipulation with or without anesthesia retention in a plaster-of paris cast for a few days and physical therapy including radiant heat and gentle massage If the cartilage slips out repeatedly operation is indicated

One of the most important considerations in most knee conditions is the maintenance of tonicity of the quadriceps muscle by active and passive movements and electrical stimulation

The Jones knee cage is a valuable brace in the ambulatory treatment of many conditions

Leg.—The important leg conditions are fractures myositis and circulatory disturbances of the arteries veins and lymphatics

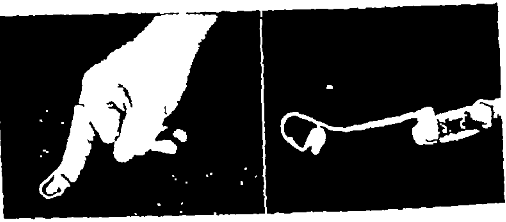


FIG. 54.—Lewin's aluminum splint for baseball finger or dropped phalangette. (Lewin, J.A.M.A., 90 June 30, 1928.)

FIG. 55.—Lewin's aluminum splint with leather wristlet to maintain thumb in slight flexion and adduction.

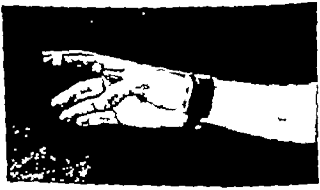


FIG. 56.—Lewin's aluminum splint with leather wristlet to maintain extension of the index finger.

ankylosis. I have divided the treatment into six sections (1) the proper care of the original causative condition whether it be arthritis sepsis a gunshot wound or a fracture through or near a joint (2) the use of physical therapy especially radiant heat gentle massage active and passive movements and diathermy (3) proper posture so that if ankylosis supervenes, the joint will be in the best position for future use (4) the proper use of splints braces and casts—this includes adjustable splints bivalved casts and wedged casts (5) manipulation both by the physical therapist without anesthesia after the use of radiant heat and gentle massage under warm water and by the orthopedic surgeon, under anesthesia In the case of manipulation great care judgment and past experience are necessary to determine whether manipulation under anesthesia is indicated and to what degree it may be reasonably carried out (6) operation which includes synovectomy osteotomy cheilectomy and arthroplasty

The most valuable literature on the subject of stiff joints is that by Sir Robert Jones Henderson Elmslie Bristow Bankart and Fisher

Hysterical stiff joints and malingerer's stiff joint I saw several cases during my army service in the camps in America where soldiers in an attempt to be released from active duty declared they had a stiff knee in flexion or extension a stiff elbow a stiff shoulder or stiff spine Under anesthesia the stiffness disappeared entirely and the soldiers were proved to be malingerers

ARTHRITIS

The writer is not a physical therapist but, because a large proportion of his work is in the field of arthritis he has had the opportunity of observing critically the effects of various physical therapy agents and agencies on individuals suffering from various conditions which to the majority of clinical observers have been correctly or not included in the term arthritis

These conditions are arthritis synovitis neuritis myositis fibrositis myofascitis bursitis tendonitis tendovaginitis and gout.

From the orthopedic point of view in the treatment of a condition like arthritis where so many remedial agents are used it is difficult to evaluate the effect of each one The operator the apparatus and the stage of the disease are variable factors The patient s statements are of value although often unconsciously incorrect

It is a combination of factors that usually causes arthritis likewise a combination of agents may be necessary to relieve or cure it. Physical therapy is an important adjunct in the treatment

The direct treatment of a patient with arthritis deformans may be divided into three divisions viz. local focal and general

The most important factor especially from the patient s standpoint is the relief from pain This must be accomplished It should be done

In the calf ruptured Achilles or plantaris tendons are very disabling and painful conditions.

In circulatory disturbances, I wish to call the reader s attention to a point at the crux of the λ made by the gastrocnemius muscle, which is usually a painful spot in certain of these conditions The treatment includes rest elevation, special exercises radiant heat and, in some cases, operation

Ankle —The important conditions in the region of the ankle include arthritis synovitis, fractures, dislocations sprains strains and static disturbances.

In cases of sprain of the ankle the treatment includes rest, elevation the application of cold, adhesive strapping or elastic compression When walking is permitted one must prescribe the proper walking shoe with modifications as needed, crutches and later on massage, exercises and contrast sprays

STIFF JOINTS

In the etiology of stiff joints the two main divisions are extra articular and intra articular factors. There are local and general factors The tissues to be considered are primarily the cartilage, synovial membrane tendons and ligaments

The cause of stiff joints is usually adhesions which may be osseous or nonosseous Osseous adhesions cause the agglutination of bony surfaces after the articular cartilage has been destroyed This produces ankylosis The nonosseous stiffness is due to the formation of adhesive fibrous bands Hemorrhage is a very important factor

In the pathology one should consider the primary and secondary factors

The symptom of stiff joints is immobility Pain may or may not be prominent. It may be the all important factor in preventing movement during the period when the joint is becoming stiff After ankylosis has occurred there is usually no pain unless the ankylosis is disturbed by force Roentgenograms may be very deceptive in determining whether complete ankylosis is present or not. I have seen roentgenograms which indicated complete ankylosis and was surprised to find considerable movement in the joint. I have seen other roentgenograms where no indication of ankylosis was present, but the joint was stiff due to fibrous adhesions and pain

The prognosis in the case of a joint that is becoming stiff or in one that is already stiff should be guarded One is given surprises in both directions.

Treatment.—The treatment of stiff joints concerns preventive prophylactic curative factors and means to prevent a relapse or re-

FIG. 59.—Roentgenogram of the lumbar spine illustrating hypertrophic arthritis. Note the bony bridging across several vertebrae

while a thorough search for the etiologic factors is being made. The joint should be put at rest The patient is put to bed, not allowed to get up for meals or to go to the lavatory The painful part is swathed with strips of gauze saturated with an anodyne lotion.

During the acute stage of all forms of arthritis, when soreness, congestion and pain of the joints are present, the first great fundamental principle of orthopedic surgery should dominate the treatment. Deformity must be prevented. Proper positions, protection splints and rest accomplish this Joints at this time should never be manipulated or strained, because the resulting swelling mechanically interferes with circulation, and trauma is done to diseased tissue. Painless active

FIG. 58.—Atrophic arthritis of the hands with deformities.

motion is encouraged After the acute stage has passed, however the joint function must be restored if possible The best results have been secured through very gradual use of the joints by exercises and occupational work Manipulation is used less and less, and the quicker method is being displaced by more gradual and, on the whole, more satisfactory daily exercise with rest periods. By this, the muscles are developed to keep pace with the increased range of motion and better circulation follows with more permanent results. If later operative procedures are necessary to obtain joint motion the muscles having been used are ready to do their share in securing motion much sooner after operation and the danger from adhesions becomes less because of this preparation

In arthritic conditions one must realize the importance of coöperation between the orthopedic surgeon and the internist.

Fig. 61—Lewin's method for strapping the pelvis for low back pain.

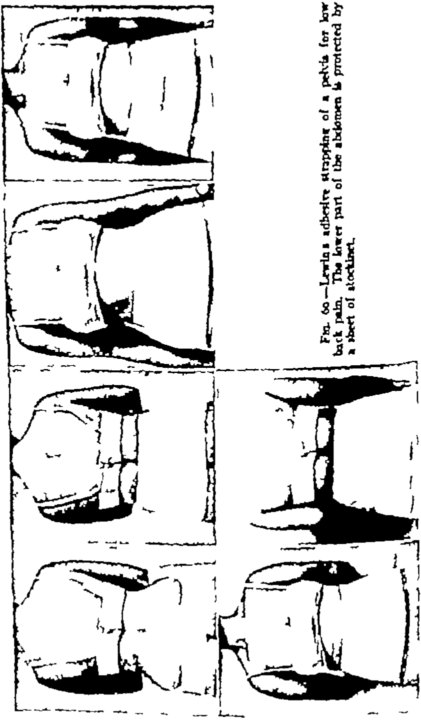


Fig. 60.—Lewin's adhesive strapping of a pelvis for low back pain. The lower part of the abdomen is protected by a sheet of stockinet.

In the treatment of arthritis of the spine one should consider traction Bradford frame heat, massage diathermy posture exercises strapping, braces belts and electrical stimulation of atrophic muscles

SCIATICA—SCIATIC SYNDROME

Sciatica, or the sciatic syndrome is a condition characterized by pain along the course of one or more of the nerves of the lumbosacral plexus the most common radiation of pain is down the back of the thigh into the leg and down to the heel The pain, however may

FIG. 64.—Plaster-of-paris body cast used in the treatment of arthritis of the upper lumbar spine.

radiate down the inner or outer border of the thigh rarely down the front. The term *sciatic syndrome* is preferable to sciatica or sciatic neuritis It is not a neuritis but a neuralgia or symptomatic neuritis Primary sciatic neuritis is a rare condition usually caused by lead arsenic, syphilis or alcoholism. The symptoms include pain with limitation of movement and in cases of sciatic scoliosis a lateral shift of the body Roentgenograms often reveal hypertrophic arthritis in the lumbosacral or sacro-iliac joints or both The differential diagnosis is important and one must exclude cord tumor and tuberculosis and malignancy of the spine In order to exclude cord tumor every patient should have a neurologic examination

The treatment includes removal of foci of infection such as in the teeth, tonsils or intestinal tract. Treatment of the arthritis of the spine includes symptomatic treatment to relieve pain Radiant heat gentle massage and diathermy are usually effective In some cases massage

ARTHRITIS OF THE SPINE

Arthritis of the spine is usually of the hypertrophic type. Pure, uncomplicated atrophic arthritis of the spine is rare. In fact there are numerous clinicians who are unable to recall one instance of uncomplicated atrophic arthritis of the spine even though they have seen large numbers of the hypertrophic type Therefore we may say that arthritis of the spine is usually of the hypertrophic type manifested by pain local and referred, limitation of motion, a stiff or even a poker spine, tenderness to movements sensitiveness to jarring, pain on sneezing coughing or straining at the stool roentgenograms revealing the hypertrophic or osteo-arthritic changes

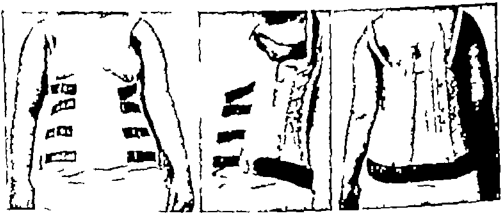


FIG 62.—Corset spine brace

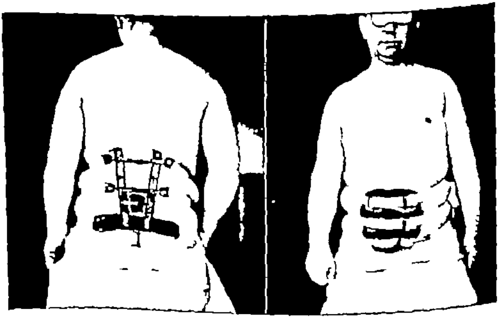


FIG. 63.—Low back brace.

and diathermy may aggravate symptoms Putti recommends a bivalved cast made with the patient in the deformed position and the use of heat from an alcohol lamp in the form of Bier's hyperemia. In some cases it is advisable to stretch the lumbar spine and limb described under 'manipulation of the spine. I have had considerable success with the combination of caudal epidural injection of 1 per cent novocaine combined with manipulation under anesthesia.

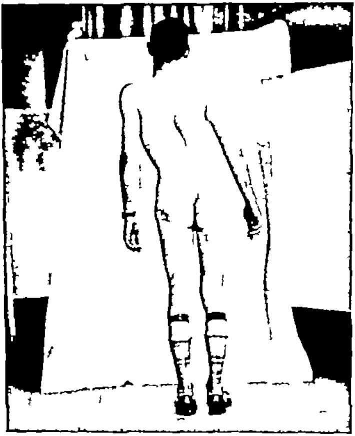


FIG. 66—Sciatic scoliosis due t arthritis at the lumbosacral joint.

BRACHIAL NEURITIS

Brachial neuritis corresponds with the sciatic syndrome. Brachial neuritis means pain along the course of one or more of the nerves of the brachial plexus The cause is usually hypertrophic arthritis of the cervical spine The symptoms include pain along the distribution of the nerves of the brachial plexus. Roentgenograms may show hypertrophic arthritis of the cervical spine The treatment includes treatment of the primary nditions or foci of infection symptomatic treatment for pain rest support heat massage diathermy and very gentle manipulation

FIG. 65—Two views of the stall bar exercise to obtain hyperextension of the spine. This is a severe exercise. It must not be prescribed where any acuteness of symptoms is present (Lewin, J.A.M.A. 88 April 3 [illegible] 9 7)

The treatment of the congenital type may be divided into early intermediate and late treatment. The measures which are of value include exercises massage and correct posture day and night. Immobilization can be secured by means of a special collar made of cotton, a brace or a cast Operation includes division of the sternal and clavicular heads of the sternocleidomastoid muscle or a plastic operation known by the name of Foederl. After operation a cast to maintain overcorrection is advisable this to be followed by a brace, exercises and massage.

Included in TRAUMATIC TORTICOLLIS should be mentioned ordinary stiff neck due to exposure to changes in temperature An ordinary stiff neck that a patient awakens with is usually due to a myositis or a neuritis. This torticollis occurs during sleep when a draft of cool air blows on the neck causing congealing of the muscles and compression of the nerves or a neuralgia followed by muscle contracture or fibrositis. The treatment includes radiant heat, gentle massage gentle manipulation and the application of a cotton collar

In OCULAR TORTICOLLIS the treatment includes, in addition to the orthopedic management the correction of the ocular disturbance

In HYSTERICAL TORTICOLLIS the physical therapist and the orthopedic surgeon can be of great assistance to the psychiatrist.

NEUROLOGIC CONDITIONS

The chief neurologic conditions to be discussed include poliomyelitis spastic paralysis brachial birth palsy syringomyelia, tabes dorsalis multiple sclerosis hysteria, pseudohypertrophic muscular paralysis ataxia peripheral nerve wounds and other paralytic and neuromuscular conditions

In the treatment of tabes the physical therapist can do a great deal in neuromuscular reëducation by the various methods such as the Frenkel series In maintaining the tone of the skin muscles ligaments and nerves massage very carefully applied is valuable Exercises under warm water are beneficial As aids in locomotion crutches canes and various mechanical walkers are useful.

In the treatment of multiple sclerosis one should try radiant heat, very gentle massage exercises neuromuscular reëducation and under water exercises Sometimes diathermy is beneficial The use of canes crutches and other walking apparatus is helpful

The same physical therapeutic measures are applicable to tabes dorsalis or locomotor ataxia and syringomyelia As is well known Charcot joint is usually found in the lower extremity syringomyelic joints in the upper extremity The physical therapy measures include rest radiant heat gentle massage neuromuscular reëducation under water gymnastics and the various aids to locomotion such as walking apparatus canes and crutches.

FIG. 67.—A cotton collar used in the treatment of brachial neuritis. It exerts traction and distraction affords support and immobilization, retains heat and prevents exposure to drafts.

FIG. 68.—Torticollis, or wryneck. Chin is pointing toward the left. Distance from right ear to shoulder shorter than on opposit side.

TORTICOLLIS

Torticollis or wryneck may be congenital or acquired. The acquired type is usually due to trauma ocular disbalance and psychic disturbances such as hysteria

The treatment of the congenital type may be divided into early intermediate and late treatment The measures which are of value include exercises, massage and correct posture day and night. Immobilization can be secured by means of a special collar made of cotton, a brace or a cast. Operation includes division of the sternal and clavicular heads of the sternocleidomastoid muscle or a plastic operation known by the name of Foederl. After operation a cast to maintain overcorrection is advisable this to be followed by a brace, exercises and massage

Included in TRAUMATIC TORTICOLLIS should be mentioned ordinary stiff neck due to exposure to changes in temperature An ordinary stiff neck that a patient awakens with is usually due to a myositis or a neuritis This torticollis occurs during sleep when a draft of cool air blows on the neck causing congealing of the muscles and compression of the nerves or a neuralgia followed by muscle contracture or fibrositis The treatment includes radiant heat gentle massage gentle manipulation and the application of a cotton collar

In OCULAR TORTICOLLIS the treatment includes in addition to the orthopedic management the correction of the ocular disturbance.

In HYSTERICAL TORTICOLLIS the physical therapist and the orthopedic surgeon can be of great assistance to the psychiatrist.

NEUROLOGIC CONDITIONS

The chief neurologic conditions to be discussed include poliomyelitis spastic paralysis brachial birth palsy syringomyelia, tabes dorsalis, multiple sclerosis hysteria, pseudohypertrophic muscular paralysis ataxia peripheral nerve wounds and other paralytic and neuromuscular conditions

In the treatment of tabes the physical therapist can do a great deal in neuromuscular reeducation by the various methods such as the Frenkel series In maintaining the tone of the skin muscles ligaments and nerves massage very carefully applied is valuable Exercises under warm water are beneficial As aids in locomotion crutches canes and various mechanical walkers are useful

In the treatment of multiple sclerosis one should try radiant heat very gentle massage exercises neuromuscular reëducation and under water exercises. Sometimes diathermy is beneficial. The use of canes crutches and other walking apparatus is helpful

The same physical therapeutic measures are applicable to tabes dorsalis or locomotor ataxia and syringomyelia. As is well known Charcot joint is usually found in the lower extremity syringomyelic joints in the upper extremity The physical therapy measures include rest radiant heat gentle massage neuromuscular reëducation under water gymnastics and the various aids to locomotion such as walking apparatus canes and crutches.

The Smart Bristow coil is of value in correcting the atrophy both of disuse and of neurotrophic origin

In the treatment of hysteria, physical therapeutic measures are of great value, especially the various hydrotherapeutic measures, including warm baths, short cold spray, contrast sprays, alternating heat and cold, gentle massage, ultraviolet rays, neuromuscular training and underwater exercises Sometimes it is advisable to apply a plaster cast to a hysterical foot in order to allow the patient to bear normal weight upon it. In some extreme cases it is justifiable to do a minor operation, such as lengthening of an Achilles tendon, in order to correct a hysterical contracture.

Metabolic Conditions

The chief metabolic conditions include arthritis gout rickets and obesity In arthritis, the most valuable physical therapeutic measures include rest, heat, massage, diathermy, negative galvanism and local applications

In a discussion of gout, one should emphasize the importance of diet, exercise and physical therapy, including ionization.

The subject of obesity is a very important one. As a general proposition, obesity is due to overindulgence in food lack of exercise and constipation There are other factors such as hereditary tendency and disturbances in the endocrine glands and of water metabolism The important physical therapy measures include massage exercises in the open air including walking tennis golf bicycle riding rowing and other sports Jumping the rope tap-dancing and setting-up exercises are very valuable Other measures include colonic irrigation implantation of acidophilus organisms, laxatives cathartics and the elimination of certain foods

So far as the question of diet is concerned in the treatment of obesity it is a general proposition that the patient s weight is the difference between his intake and his output. There has been considerable discussion on the subject of endogenous and exogenous obesity, but when all the evidence is weighed it comes down to the simple proposition that the patient s weight is the difference between the amount of food taken in the type of food the metabolism of the food and the energy output such as in exercising, and his excretions.

There is undoubtedly a definite type of constitution of the individual—an inherited constitution Endocrine factors are undoubtedly important, but the exact nature has not yet been determined Failure to recognize the factor of obesity and to institute proper procedure has been the cause of many failures in the treatment of conditions involving the extremities and the lower back. These conditions are chiefly arthritic metabolic and mechanical including flat feet and painful heels

The reader is referred to such works as McLester Evans and Strang and Newburgh. Fads and fancies in diet are largely due to misinformation fostered by the cultists or as a result of prejudice of unthinking people

Obesity is a very important consideration in orthopedic cases especially from the mechanical standpoint in the following conditions anterior poliomyelitis flat feet, painful heels sacro-iliac disturbances

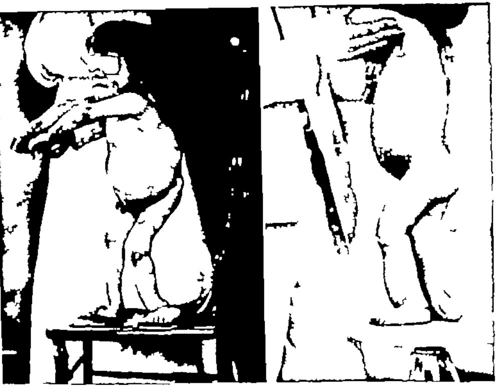


FIG. 69 —Extreme deformities occurring in twins who had rickets.

arthritis of all the joints especially those of the spine hip knee and ankle The overweight child is the precursor of the overweight adult

Fashion in recent years has decreed according to Barborka that the figure of women should be sylph-like to conform to this many women have employed on their own initiative many ridiculous dietary measures Not infrequently this has led to extreme under-nutrition to ill health and even death It is the physician s duty to point out the limits of reduction and that health is more to be desired than a fashionable figure

After an injury to the foot or ankle or knee such as occurs in industrial conditions especially fractures and dislocations of the lower

extremity, obesity may be a very important stumbling-block which favors prolonged disability

Endocrine Disturbances

Under endocrine disturbances the physical therapist is especially concerned with such conditions as obesity, leanness, Fröhlich's syndrome and slipped epiphysis

The chief glands of internal secretion which are on a fair basis of scientific therapeusis include the thyroid, parathyroid pituitary, adrenal and ovary

Physical therapy measures include support, casts, splints, massage and diathermy Endocrine therapy and sometimes operations are indicated

Circulatory Conditions

The most important circulatory conditions include varicose veins, endarteritis obliterans thrombo-angiitis obliterans Raynaud's disease and causalgia Thrombo-angiitis is known as Buerger's disease. Space does not permit description of the various tests for the efficiency of the circulatory apparatus

The best treatment for varicose veins is the injection of sclerosing solutions This is a minor procedure in the hands of a qualified surgeon.

It has been stated that 95 per cent of Buerger's disease cases occur in men and 5 per cent in women, which is just the opposite of the figures for Raynaud's disease

The importance in the treatment of circulatory disturbances is to improve circulation. The means of accomplishing this include rest elevation of the limb heat elastic compression diathermy locally and to the cervical and lumbar sympathetics, special circulatory and postural exercises. Operations on the veins, arteries and sympathetic nerves are not discussed here

The most valuable postural circulatory exercises are those described by Buerger * under the conservative treatment of thrombo-angiitis obliterans He says "When the disease is well developed distinct intermittent claudication being present and fairly marked pain with or without trophic disorders it is advisable that the patient remain in bed for several weeks or even longer or at least that walking and standing be completely interdicted Therapeutic measures should be directed toward the conservation of warmth enhancement of the circulation the prevention of traumatism, and the treatment of local conditions trophic disorders or gangrene when these supervene."

The author has suggested that certain passive exercises may be of value in inducing hyperemia or rubor in the affected limb and, therefore, therapeutically beneficial in increasing the blood supply

* Buerger Leo Circulatory Disturbances of the Extremities, Ed. 1, Phila., W B. Saunders Co., 1914.

This method is the logical therapeutic outcome of Buerger s method of diagnosticating impairment of circulation of the lower extremities, in that it uses the phenomenon of induced rubor or induced hyperemia in a therapeutic way If the method be carried out daily for a sufficiently long period it is of greater value in improving the circulatory conditions and in increasing the blood supply than any of the other mechanical or thermal means that are at our disposal.

The procedure is as follows "With the patient lying supine, the affected limb is elevated to from 60 to 90 degrees above the horizontal being allowed to rest upon a support for from 30 seconds to 3 minutes the period of time being the minimum amount of time necessary to produce blanching or ischemia. As soon as blanching is established the patient allows the foot to hang down over the edge of the bed for from 2 to 5 minutes until reactionary hyperemia or rubor sets in, the total period of time being about 1 minute longer than that necessary to establish a good red color The limb is then placed in the horizontal position for about 3 to 5 minutes during which time an electric heating pad or a hot water bag is applied care being taken to prevent the occurrence of a burn. The placing of the limb in these three successive positions constitutes a cycle the duration of which is usually from 6 to 10 minutes These cycles are repeated over a period of about one hour some 6 to 7 cycles constituting a séance

"The number of séances cannot be categorically stated but should vary with the case. In a general way they should occupy at least 6 to 7 hours a day that is every alternate hour during the daytime During the hours of rest heat is applied continuously in the form of an electric pad hot water bag hot air apparatus or electric lamp In the opinion of the author this method does far more to improve the circulation than either the application of superheated air (so-called baking treatment) or the diathermic treatment.

"The length of time of its application may require modification according to the manner in which the procedure is borne In some cases pain induced by elevation may necessitate a diminution in the period of elevation

"It is not possible to lay down hard and fast rules as to the exact application of this method in any given case Its employment should be varied according to the requirement of each and every clinical stage and the patient s response."

In the treatment of arteriosclerosis Buerger recommends several methods of improving the circulation.

These include first the postural treatment second the hot air treatment third, the diathermic treatment fourth the heat of electric lamps fifth, the thermophore

The postural treatment which consists in the induction of a reactionary hyperemia in the affected part by preliminary elevation of the leg followed by depression of the limb in a dependent position

may be used with some benefit in almost all cases, except where gangrene has already become extensive, where a phlegmon has developed or where such changes of position are too painful to the patient. When recent extensive thrombosis has taken place, it is also contra indicated

The postural treatment, or exercises to induce rubor and an accelerated circulation, must be varied in its method of application in each and every case "The period of elevation should be the minimum amount of time necessary to produce a frank blanching of the foot. This is usually about 30 seconds to 3 minutes, depending upon the degree and extent of the vascular obstruction. The next period of depression (or of the hanging leg) is to be prolonged about 1 or 2 minutes beyond the time necessary for the induction of distinct rubor An abridgment of this is then warranted when the patient complains of increased pain in this position, or if the pain becomes unbearable after a given duration of time The third position of rest in the horizontal may be extended at will beyond 3 minutes, provided that this does not suffice to give enough repose to the patient. In general, it should be longer in the atherosclerotic cases than in the younger people affected with thrombo-angiitis since the former may find the treatment onerous unless sufficient intervals of rest are provided

'The position of the resting limb in all forms of obstructive arterial disease has not received attention from the clinicians. If careful observations on the appearance of such limbs in varying postures be made, especially after the induction and abatement of reactive circulatory manifestations it will be noted that the color of the foot varies considerably when in the horizontal plane. While a normal or slightly diminished flesh color is not infrequently seen even in advanced arterial disease, the affected foot will often evidence varying degrees of pallor This may affect but one or more toes or the fore part of the foot, or it may involve even some of the distal portions of the leg; the dorsum or plantar aspect of the foot may show patches of blanching alternating with pinkish or slightly cyanotic areas All of these color manifestations must be interpreted as indicating a circulatory insufficiency in this position, and as such we may deduce lessons of prophylactic and therapeutic value—to wit, that such limbs are not to be allowed to stay during their period of rest, in the horizontal position but somewhat depressed just enough to bring about color evidences of circulatory activity After testing the angle necessary to bring about the return of almost normal color the patient must be instructed that this particular position is to serve as his horizontal. Indeed it is well even when asleep to arrange the bed so as to conserve the angle previously arrived at, for harmful as is the continued stasis induced by prolonged standing or walking so also is one of continued ischemia, even if but slight. A position of elevation universally regarded as harmless must be avoided because of its depleting effect.'

Pseudohypertrophic Muscular Paralysis

This condition is variously known as pseudohypertrophic muscular paralysis and progressive muscular dystrophy

The cause of the condition is unknown. The signs and symptoms include the following There is a history of delayed walking sometimes until the third or fourth year Tiptoe walking is the rule. The gait is awkward waddling and unsteady with inability to go up and down stairs. Children fall frequently and are usually unable to arise without assistance They tire easily There is a marked lordosis and a protuberant abdomen. Usually the calf muscles are enlarged and very firm There is a peculiar facial expression which is dull and mask-like with inability to elevate the angles of the mouth so that when the child smiles the lips spread out sidewise but the angles of the mouth are not elevated In walking the feet are wide apart and sooner or later they assume a position of equinus or toe drop They are swung forward rather than lifted and carried high to clear the ground The child sways from side to side and he cannot sit down slowly—he collapses into a chair unless he uses his arms and hands to break the fall Winged scapulae are due to muscular atrophy There are noted a wasp-waist and loose shoulders. Stumbling and falling are prominent features. If the child can rise from the lying position on the floor he usually does so in a classic way He turns over on his face he rests on his elbows and knees, climbs up on his legs by putting his hands on his ankles then the legs then the knees and then the thighs and finally by a supreme effort, stands up

The treatment of this condition includes no specific remedy For many years I have used hypodermic tablets of adrenalin 3/200 of a grain each, dissolved under the tongue three times a day More recently Kure and Okinaka advocate the use of adrenalin and pilocarpine subcutaneously The dose for adrenalin is 0.2 to 0 3 cc. of a 0 1 per cent solution The dose for pilocarpine is 0 1 to 0 2 cc. of a 1 per cent solution The injections are repeated daily or every second day until at least 50 injections are given

The physical therapeutic measures are as follows The first warning is to avoid fatigue. Electricity is of value in maintaining good tone and circulation Massage is of some value. Hydrotherapy is valuable. In order to teach these patients to go up and down stairs it is advisable to use a set of 5 or 6 narrow stairs with a balustrade on each side Retention apparatus as a rule is not highly beneficial As a means of preventing contractures and deformities, it is advisable. A light removable plaster cast or brace may be used to hold the foot at a right angle or a knee in extension or to support a scoliotic back

Tendon lengthening and tenotomies, when indicated should be performed very carefully because of the danger of losing what little

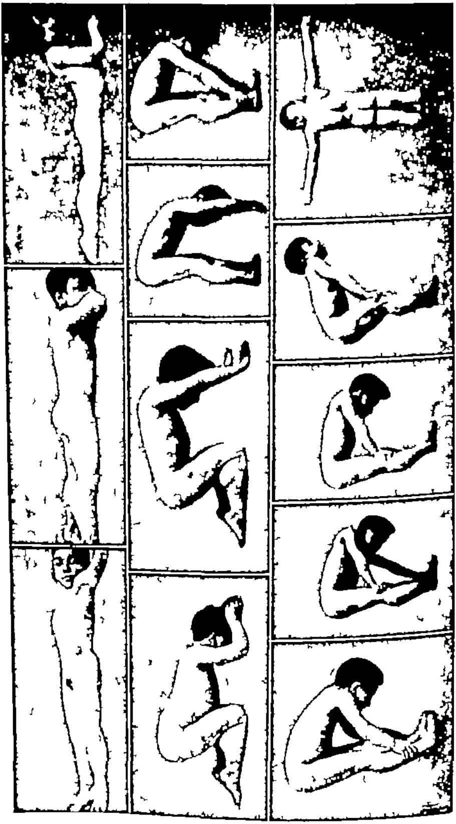


Fig. 70.—Twelve views of child with pseudohypertrophic muscular dystrophy arising from the ground in the typical manner (climbing up his legs." (Lewin, J A.M.A., 67 August 7 16)

tone or power their muscles have and because of the danger of producing the opposite deformity which may be more disabling

Shoes and Their Modifications

In a discussion of shoe modification first of all one must consider the type of shoe that is advisable for children women and men As a general proposition, one may say that a shoe should be straight lasted round toed have a moderate height of heel and a rigid shank

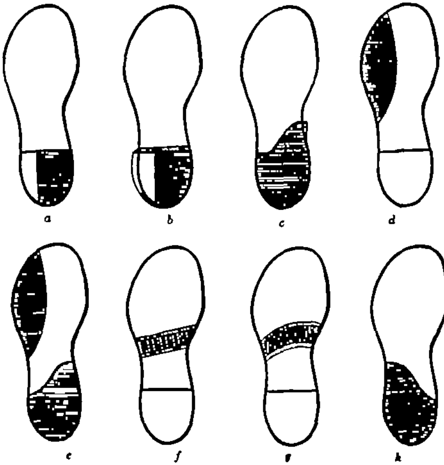


Fig. 71—The most commonly prescribed modification f shoes (The left shoe is shown.)
a. Elevation f inner border f heel
b Elevation of inner border of flared heel.
c H O Thomas heel—prolongation f rward and levation f inner border
d. Elevation of outer border f sole
e. Combined Thomas heel plus levation of outer border of sole
f Metatarsal cleat
g Metatarsal crescent
h. Reversed Thomas heel Outer border prolonged forward and elevated.
The ket hes were made by D D H. Levinthal
The modifications most commonly used are the special heel f H. O Thomas, modification f the sole and the metat rsal crescent or cleat. [Philip Lewin, J Bone & Joint Surg 665-669 (July) 93]

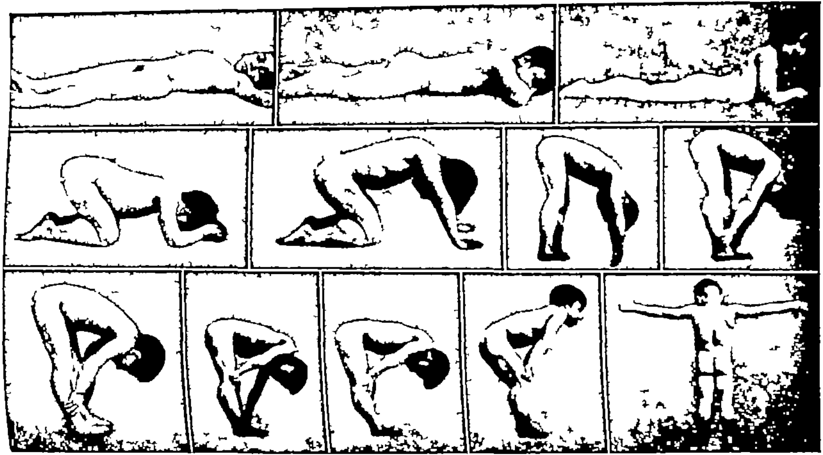


Fig. 70.—Twelve views of child with pseudohypertrophic muscula dystrophy arising from the ground in the typical manner of "c limbing up his legs." (Lewin, J.A.M.A., 87 August 7 926.)

muscle pull or muscle imbalance produces disturbances of posture, but to a certain extent these inherited tendencies can be overcome. Bad posture in many instances is only a result of habit and by the exertion of will power and by proper exercises, good posture habits can be acquired Deformity and disease have an influence on posture

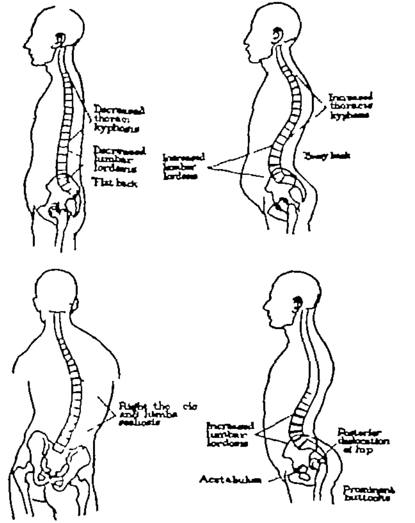


FIG. 72—Several abnormal conditions of the spine that are the result of congenital disorders or poor posture. (Lewin, Hygeia, 6, January 1928)

tuberculosis infantile paralysis and arthritis are diseases that are important in this connection

Good posture should be taught to the young child and should be given attention throughout life It is of great importance that the child form correct habits of posture as early as possible, in the home in kindergarten and in school Poor posture is said to be on the increase and there is no doubt that it adds greatly to the stress and strain of

It must be narrow in the heel and through the waist of the foot, but wide through the ball

There is comparatively little difficulty in obtaining properly shaped shoes for children and men, but for girls and women the matter is entirely different Women are the victims of two things one is style and the other is the shoe salesman Women prefer to fit the eye rather than the foot, and please the eye rather than their husband's good sense

The chief modifications in shoes include modifications of the heels, soles, counters and the big toe region The chief modification of the heel is the Thomas heel, which is longer and higher on the inner border than the outer border This compels the individual to walk over the proper walking angle, so that a weight-bearing line dropped from the middle of the patella bisects the tibia and the astragalus.

The chief modification of the sole is the elevation of the outer border where the highest point of the wedge should be under the base of the fifth toe.

Modifications of the counters include the removal of the counter for irritation of the heel and the prolongation of the counter on the inner border to protect and support the scaphoid, first cuneiform and base of the first metatarsal

Modifications in the region of the big-toe joint include making the sole rigid, so there will be no motion in the big toe joint, which may be beneficial in relieving the pain in cases of osteo-arthritis of the big-toe joint.

The chief modification of the sole is what is known as a metatarsal bar or cleat, which consists of a strip of leather secured between the layers of the sole at a point just behind the heads of the metatarsal bones

Posture *

There is heaith as well as beauty in correct carriage, and many serious disorders of the human body are due in whole or in part to poor posture

An imaginary plumb line dropped from the side of the head should pass through the ear and through the middle of the shoulder, hip, knee and ankle bone if a person has a correct standing posture. By performing the following movements one will attain excellent form (1) stand with the back against the wall (2) let the head and buttocks touch the wall but place the heels forward four inches (3) flatten the lumbar region, attempting to touch the wall with the lumbar spine and (4) holding the body erect shift the weight forward to the balls of the feet and step off maintaining the body in this position.

A person inherits from his parents and ancestors a certain type of back and a certain type of posture just as he inherits many other characteristics Muscular weakness also is inherited and unequal

* Lewis Philip Hygeia, 6 3 (Jan) 1928.

and mouth to function better The person with erect carriage actually thinks better he is more level headed

In the chest also poor posture causes disturbances The cramping results in improper physiologic action of the heart and lungs The diaphragm the large muscle that separates the thoracic from the abdominal cavity cannot do its work properly when posture is un natural.

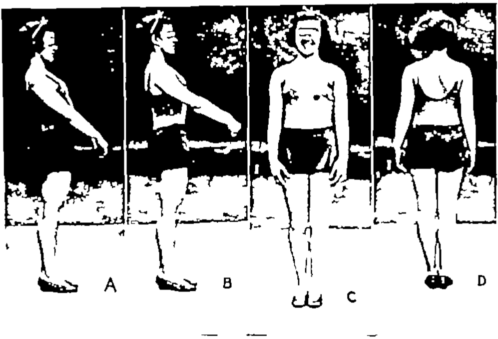


FIG. 74—A, poor posture due to exaggerated lumbar lordosis B C and D correct posture.

Proper support is not provided the abdominal organs—stomach liver gallbladder pancreas small intestine large intestine and omentum—when posture is bad they are cramped and forced out of their normal positions With the stomach at a lower level intestines pushed down kidneys improperly supported and strain on the various suspensory ligaments it is simple to deduce what symptoms follow The circulation of these tissues is impeded and constipation an important factor in the production or aggravation of many chronic conditions results

The pelvic organs in persons of both sexes may suffer materially In women the effects of poor posture often reflect themselves in the uterus ovaries and fallopian tubes

Poor posture of the lower extremities results in mechanical and other disturbances chief of which are strain on the hip joint and mechanical strain on the knee joint ankle and foot Undoubtedly many

both child and adult life, it also exposes the individual to the possibility of superinduced infection and trauma.

The spine is a flexible rod made up of segments, at one end of which sits the head and at the other end of which sits the person The spine has a normal front to back (anteroposterior) curve, it curves forward, backward, forward and backward again as one progresses from the neck to its base but in the lateral or side to side, plane there are no normal curves Any lateral deviation involving more than

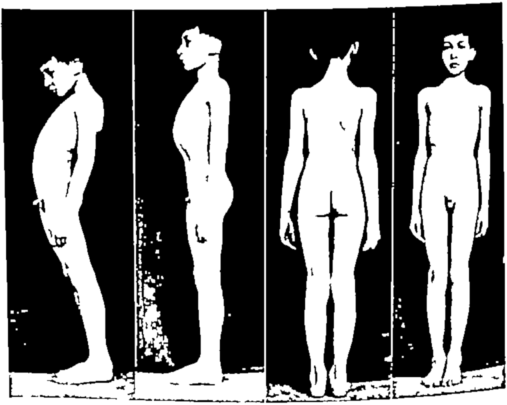


FIG 73—After three weeks of medical gymnastics, this boy's posture improved from the condition shown on the left to the erect carriage illustrated on the right. [Philip Lewin Hygeia, 6 3 (Jan.) 1928]

one vertebra is called scoliosis. As it is a flexible rod, one portion of the spine cannot be changed without a compensatory change in at least one other portion

Man was not intended to walk upright. Many human disorders are penalties for his having assumed the upright position Without good posture the brain heart, lungs liver kidneys pancreas muscles and ligaments are hindered in proper function and elimination from the gastro-intestinal tract is retarded.

Erect carriage of the head and proper curving of the neck permit the muscles ligaments bones joints blood vessels brain eyes ears nose

and mouth to function better The person with erect carriage actually thinks better he is more level headed

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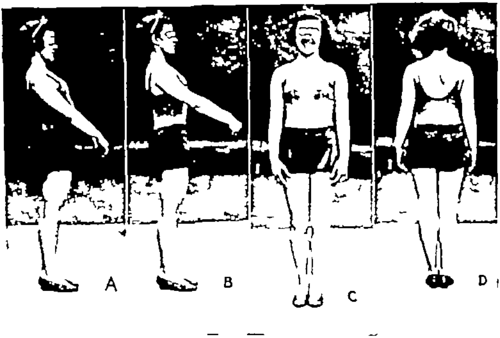

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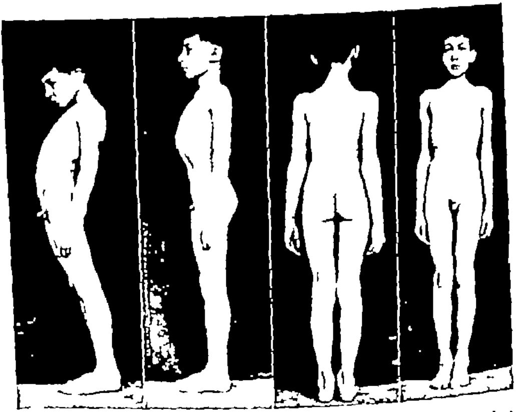

FIG 73 —After three weeks of medical gymnastics, this boy's posture improved from the condition shown on the left to the erect carriage illustrated on the right. [Philip Lewin, Hygeia, 6 5 (Jan.) 1928.]

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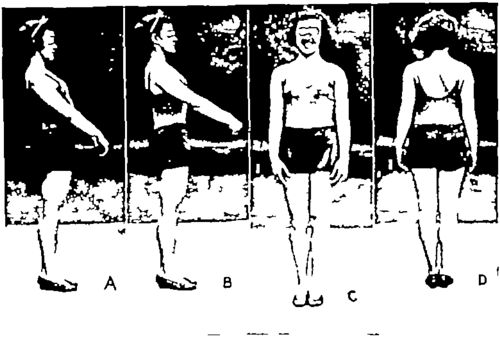

FIG. 74.—A, poor posture due to exaggerated lumbar lordosis B C and D correct posture.

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The pelvic organs in persons of both sexes may suffer materially In women the effects of poor posture often reflect themselves in the uterus, ovaries and fallopian tubes

Poor posture of the lower extremities results in mechanical and other disturbances chief of which are strain on the hip joint and mechanical strain on the knee joint ankle and foot. Undoubtedly many

cases of arthritis of the knee and hip are traceable to basic mechanical disturbances that have been in operation over a period of many years.

Flatfoot is a result of poor posture in many cases and may be a disabling condition The combination of a mechanical disturbance, such as pronation of the foot with strain, overactivity, injury or infection, is a common cause of foot disability

The methods of recording posture are the photograph, the schematograph, which was invented by Dr Mosher and Prof Lesley of Leland Stanford University and is a camera-like instrument with a focusing lens and a series of mirrors, by which an image is thrown on a sheet of clear glass on which is superimposed a piece of tracing paper and the silhouetteograph devised by Norman Fradd, which makes a graphic record of the posture by an arrangement for photographing the individual in silhouette

Roentgenograms are of value in determining the position and shape of the bones They often reveal definite unsuspected disease conditions.

Treatment.—The treatment of postural defects consists of prophylactic and remedial measures Prophylactic measures consist of such considerations as balancing the pelvis in cases of inequality of the length of legs Attention to the feet is important The remedial agents are rest medical gymnastics and support. The mattress must be made rigid by the insertion under it of boards or a wooden frame. The Bradford or Whitman gas-pipe frames are valuable in some cases. Stretching consisting of head traction leg traction, pelvic traction, or combinations of two of these three is valuable as preliminary treatment.

Medical gymnastics consist of postural corrective, flexibility, power increasing breathing and relaxation exercises In postural exercises, the patient is taught to stand tall, sit tall, lie tall and think tall. He learns to walk with his chest thrown forward his abdomen drawn in, his lumbar curve flattened his shoulders well back and upward and his head upward so that he looks out of the centers of his eyes the chin is drawn straight back He walks "chesty"

Corrective flexibility and power increasing exercises are self-explanatory Breathing exercises such as those emphasized by Goldthwait and Klein, are valuable. Relaxation exercises have a definite place in this treatment. The so-called stall bar exercise is of considerable value in low back conditions Swimming and ballet dancing are excellent.

When supports are necessary a simple corset is to be considered. The orthopedic surgeon in some cases may prescribe the wearing of a corset reënforced either by a steel frame or by an aluminum cage Braces celluloid jackets aluminum jackets and plaster-of-paris casts are sometimes necessary in severe cases. Plaster casts may be removable.

Physical therapy consisting chiefly of massage is of great value Hydrotherapy heliotherapy phototherapy and tonics have their places in the treatment.

I have designated the following ten commandments of good posture

1 Stand tall
2 Sit tall.
3 Walk tall and chesty' with weight transmitted to balls of feet.
4 Draw in abdomen pulling it backward and upward
5 Keep shoulders high and square
6 Pull chin straight backward toward collar button
7 Flatten hollow of back by rolling pelvis downward and backward
8 Separate shoulders from hips as far as possible
9 Lie tall and flat
10. Think tall.

Conclusion

In concluding this chapter I wish to emphasize the importance of physical therapeutic agents in the prevention and correction of deformities and disabilities of the extremities In every community there should be at least one institution where physical therapy can be given in an ethical manner under the control and guidance of a licensed practitioner of medicine

The author wishes to express his thanks to Lea & F biger for the use of con siderable portion of this manuscript and many f the illustrations to be used in his f rthcoming book, *The Principles and Practic f Orth paedic Surgery* ho to W B Saunders Company f the use f some f the manuscript and some f the illustrations from his book, *Orthopaedic Surgery for Nurses.*

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CHAPTER TWELVE

PHYSICAL THERAPY IN PLASTIC SURGERY

VILRAY P BLAIR M.D and JAMES BARRETT BROWN M.D

PHYSICAL AND OCCUPATIONAL THERAPY IN GENERAL

The application of physical and occupational therapy plays an indispensable rôle in the care of many patients who have to undergo extensive plastic repairs of defects.

Plastic operations may include the repair of recent lacerations. Again a rather long series of plastic operations may be necessary to overcome serious defects in facial appearance and function such as deforming scars from burns or scars following operations for car cinoma Finally the plastic operation may be performed to restore function to a part, as in a temporomaxillary ankylosis or to replace deforming scars with contractures about the trunk or extremities In all these conditions physical therapy must play its part if the ultimate aim of the operative procedure is to be attained

Severe scarring and contracture deformity about the hand and fingers may be taken as a given case After a long period the part may still be swollen and congested or it may show atrophy and poor blood supply Heat hydrotherapy and massage for one to four weeks prior to the proposed reconstructive operation will usually improve the blood supply overcome a certain amount of the contracture deformity limit the degree of atrophy from disuse and altogether so improve the con dition of the part as to assure the best possible operative result. Following operation on the hand physical therapy in the nature of proper splinting is immediately introduced. A little later hydrotherapy is employed and as soon as the healing of the wounds permits massage and muscle-training exercises are added to the treatment Long after the surgical wounds have healed the daily use of massage muscle-training exercises active exercises and finally work or play are necessary and should be persisted in until the greatest possible func tional restoration is secured (Figs 1 8)

PHYSICAL THERAPY AGENCIES IN PLASTIC SURGERY

In plastic surgery the following physical therapy agencies are most commonly used

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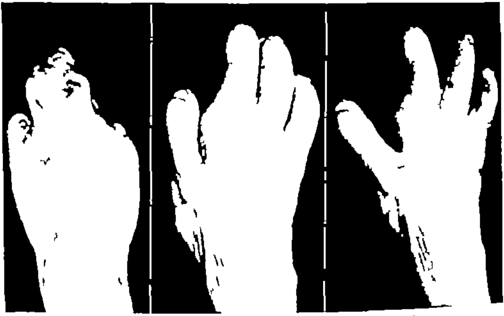


Fig. 1 Fig. 2 Fig. 3

Fig. 1.—The hand has been left a scarred mass, following a severe burn.

Figs. 2 and 3.—Reconstruction of hand by removing scar to establish joint movement and covering the dorsum with a pocket flap from the abdomen. The space between the fingers was restored with free grafts after the abdominal flap was in place.

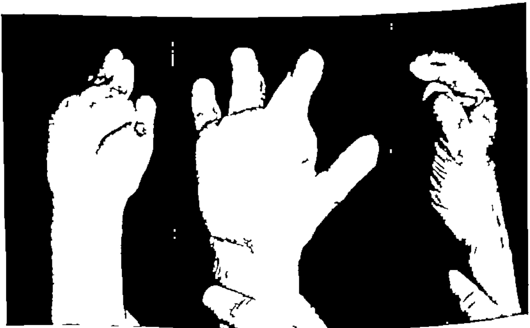


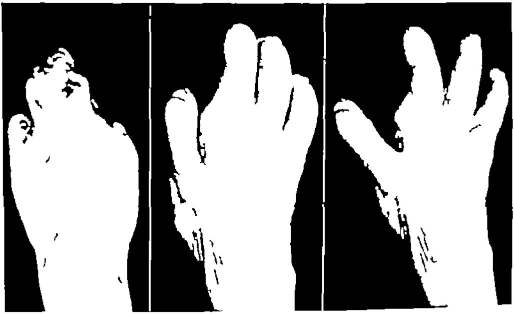
Fig. 4 Fig. 5 Fig. 6

Figs. 4, 5 and 6.—Different views of same hand.

FIG. 7—Patient at work in occupational therapy shop after restoration of hand shown in Figs. 1-6

FIG. 8—Patient has made all articles shown. Note saw with handle modeled in wax so that she could use it easily

In addition t the reconstructive work on the hand, it has been necessary to do extensive work on the neck t free contractures that held the head flexed on the chest.



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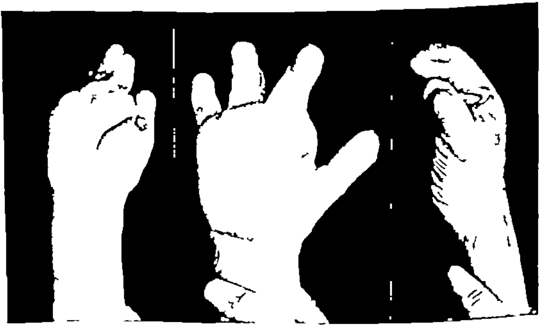

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Radium
1 To reduce scar tissue, as in keloids

Occupational Therapy —Occupational therapy as well as the simplest massage exercises and baths is of real importance for stimulat

Fig. 9 Fig 10

Fig. 9—Boy with extensive thick, heavy scarring and contracture of arm t side, and this side of chest and flank.

The arm was entirely freed by release of the scar and complete section of the origin by the pectoralis major and latissimus dorsi muscles and advancement of them higher on the thorax. The resultant defect was grafted with thick split grafts taken from the thighs. An area f more than 150 sq. in was grafted t one time

Fig. 10—Severe contractures of axilla (anterior fold and apex) and of neck that has pulled jaw down int an pen bite of cm. Note pinch small deep grafts (applied elsewhere) that have resulted in healing of the area, but not in release of deformity

The head, neck, and lip were restored t normal position in one operation by excising the scars and covering the defect with thick split grafts.

The arm was freed and the xillary apex and anterior fold were covered with split grafts in one operation.

Massage

1 To prepare a part for the proposed operation
2 To stimulate the blood supply, as in the base of a pedicle flap
3 To attempt to reduce the amount of scar tissue
4 To loosen up a scar and overcome a tendency to retract or contract
5 To restore function, especially about the joints
6 To loosen the contracture that takes place under skin grafts and flaps

Dry Heat as from an incandescent bulb, infra red baker, hot water bottle, or electric pad

1 To relieve pain
2 To stimulate the formation of healthy granulation tissue preparatory to a skin graft
3 To improve circulation (a) to stimulate, (b) preparatory to massage
4 To combat low-grade infection

Hydrotherapy as local or general baths, local or general salt baths, whirlpool baths hot wet packs, contrast baths (hot bath 15 min., cold bath 2 min. usually local)

1 To relieve pain
2 To stimulate a healthy bed of granulation tissue
3 To stimulate circulation as warm saline packs applied about the base of a pedicle flap
4 Preliminary to massage and exercise
5 To overcome infection

Dry Cold, as from ice-bag

1 To overcome traumatic or postoperative swelling

Ultraviolet Rays, as from quartz light or from direct sunlight

1 To stimulate healing
2 To improve general condition of patient especially in children with rachitic tendency
3 To tan, if possible a skin graft or flap
4 To overcome a low-grade infection as pimples, preparatory to plastic operation

X Rays

1 To overcome (1) low grade skin infection, (2) almost any type of surface cellulitis including erysipelas (3) boils, (4) adenitis, (5) abscess formation (6) Ludwig's angina, (7) acute parotitis
2 To reduce scar tissue

Extensive Burns

The immediate care of extensive burns necessitates the relief of pain and the treatment or prevention of shock. The immediate local treatment is subject to so many varying possibilities, and the available methods of treatment may be so limited that no one method can ever be universally relied upon. Any treatment that allows crusts to remain on wounds under which there is usually a collection of pus, may be sufficient for superficial burns but for deep burns in which the full

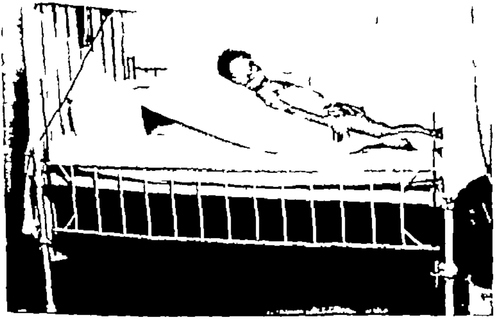

FIG. 12.—Electric lights supply warmth. By having them placed high and the sheets over the whole bed, easy access to the patient can be had by the nurses, and the patient has as much freedom of movement as anyone in bed. The lights may be placed across the top of Balkan frame; a special frame may be made to fit adults' or children's beds.

This patient is on a Bradford frame elevated to allow irrigating fluid to run off through the rubber sheet over the end of the bed into the bucket. Every hour or so 500 to 1,000 cc. of saline solution are poured over the patient to help prevent crusting. This position and the irrigations are of course, optional. Dakin's solution, acriflavine, hexylresorcinol, or any other desired antiseptic may be applied on loose gauze dressings. The patient is free from tractions or restraints. Normal active full-range movements are encouraged (and rewarded) and in this way many secondary contractures may be overcome or avoided even though there may be severe contracture in the burned area.

The change of treatment each day is good for the patient's morale, and as soon as possible the patient is allowed to be up and around. A wet dressing is preferable at this time and it is left on until the following morning when it is soaked loose in the bath. Grease dressings are rarely used if skin grafting is to be done because grease does not promote dry firm granulations. As a substitute for both the wet and the grease dressing a water soluble jelly to which has been added 2 to 5 per cent of sodium chloride may be used. (Reprinted from the Dallas M. J. (May) 93)

ing the patient mentally and for infusing spirit into him Many patients completely disheartened with a long series of surgical steps may be reclaimed mentally by the instruction and guidance of an occupational therapist

If the elaborate outlay found in most large surgical clinics is not available, the surgeon will often find the application of these principles directly advantageous in securing surgical results even if he has to combine the work with his own (Figs 7 8 and 11)

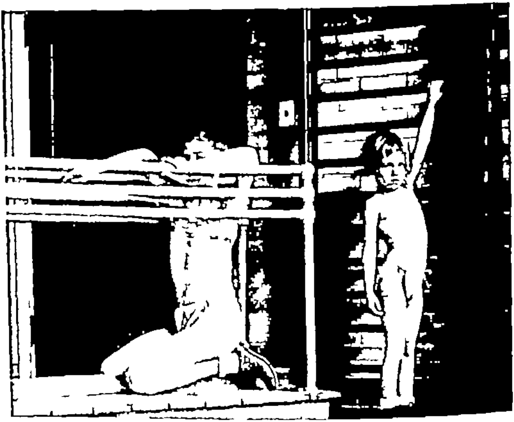

Fig 11—Boy and girl of Figs. 9 and 10 shown in physical therapy department.

The boy shows almost full extension of arm and has received great benefit from instruction and training in this department. The nerve supply of the pectoralis and latissimus was not interrupted as evidenced by good power of adduction of the arm.

The girl is able to close her mouth and raise her head. Her arm movement has been restored to complete extension in one operation.

Over large joints such as the axilla the thick split-skin graft is admirably adapted. Soon after healing is complete exercise can be resorted to that actively resists the contracture of the base of the graft. Children are excellent subjects and even a simple trapeze will be of great benefit if an established department is not available. Intelligent children are frequently turned loose on their own initiative after the idea of active exercise is explained to them, and they rapidly rehabilitate themselves

Note that the thighs of both patients from which the grafts were cut are healed. In the girl there is but faint evidence of the wound, although the photograph was taken but 19 days after the operation (Department of Physical Therapy Shriners Hospital.)

thickness of the derma has been destroyed some plan for surgical cleanliness should be employed. No single method is applicable to all cases but with the general plan of frequently changed hypertonic dressings and with close attention to mechanical cleansing at the time the dressings are changed most patients will develop clean firm granulations ready for grafting within four weeks (Figs 12 and 13)

After sloughed tissue has separated and there is no further toxicity from the burned area there is left a denuded area that requires restoration of surface covering of sufficient thickness This restoration should be made as speedily as possible for the conservation of function health and comfort Any treatment or lack of treatment that delays restoration is an economic waste Especially important is surgical cleanliness for burns of the hand and arm, for here the important tendons and joint capsules are so close to the surface that prolonged chronic infection in granulations over them may result in permanent deformity

Saline Bath and Dry Heat.—For widespread denuded areas of the body and extremities the combined use of the saline bath and dry heat is most efficient for cleaning these wounds surgically in preparation for skin grafting The patient is placed in a warm salt bath for one to three hours a day, and then lies without dressings on a bed covered with sheeting, to which heat is applied by a string of electric lights above the patient (Figs 12 and 13)

There are several distinct advantages in this method of care

(1) The patients are extremely grateful because of their freedom from painful dressings Patients, both adults and children who have practically lost their morale from pain and discomfort are frequently made comfortable after 5 to 10 min. in the bath They may be put in the first time with clothes and dressings left on, and then after soaking for some time the dressings may be cut loose and removed without pain

(2) The method is probably the least expensive of any and may be carried out in the home

(3) After the routine is once established nursing care can almost supplant the care of the doctor except for daily inspection and necessary changes in care

(4) Placing the patient unrestrained in the bath and in the bed will both encourage active and passive motion and reduce contractures to a minimum. Restraints in the form of splints bandages and loops over extremities can almost universally be avoided Contracture from surface loss can be remedied satisfactorily only by replacing tissue The relief obtained from secondary contractures by splinting will be lost in a few hours after removing the restraint

(5) As soon as the patient is able to be up and around some sort of dressing must be substituted for the dry heat and for this hyper

FIG. 13 —The tub—a portable one—is shown tipped up and without water (for photographing) There is a support for the head, and pads are elsewhere The bath is kept comfortably warm and up to 5 per cent sodium chloride may be added. Cleanliness is, f course important but no attempt is made at sterility If the patient cannot be easily moved, both bladder and bowel content may be passed into the tub, cleaned out, and fresh saline added. For dults, a long tub is necessary if they are to recline and the hydrotherapy tub with a canvas sling that the patient lies in about 8 to o in. from the bottom f the tub, with the legs and arms free, is satisf ctory For badly burned patients, even though a fatal outcome is expected, this method of care is one of the most comfortable and may be continual For patients that are first seen with badly matted and stuck dressings, soaking in the bath is probably the best, quickest, and least painful method f removing the dressing and crusts.

This patient was put in for 2 r 3 h each morning and frequently slept part of the time

It is necessary t have a nurse or ttendant constantly present for children. [Reprinted from the Dallas M J 17 59-70 (May) 193]

Active movement about joints may be started when it is certain the graft can stand it. Deep massage may help to loosen grafts from their bases and also help smooth them out if there is a tendency to wrinkling from contracture of the base There does not appear to be accurate data on the reasons for variations in the color of skin grafts Although they rarely 'tan on exposure to actinic radiation there may be some improvement in color (Figs 7 8 and 11)

Pedicle Flaps

Physical therapy of a tedious sort may be necessary for pedicle flaps that have a sluggish blood supply Light massage with the finger tips along the flap three to six times every five minutes may help replace the inadequate pulse and if this is carried out intelligently by the nurse, an apparently doomed flap may be saved The use of warm wet packs around the base of the flap is valuable care should always be taken to avoid blistering and it is best to have the packs tested and applied with the fingers rather than with forceps

Deep rotary massage of these flaps after they have been completed may free them well from the base and here again actinic radiation may be tried for color improvement if the flap remains a dead white.

Cleft Lip and Palate

Quartz light treatment local and general has apparently been of great value in some cases that have not withstood operation well For mild cellulitis and infection of the lips local radiation has proved especially beneficial

In infants and children it is necessary to keep the hands away from the mouth and light splints are used to prevent flexion of the forearms

Speech training is almost as important for good speech as is repair of the palate With intelligent parents and patients this may be accomplished at home by following simple rules but most patients do best in class or under the supervision of one who is trained in the work.

Operative Trauma

For swelling following operations (without infection) cold applications simply applied are the most satisfactory One caution about the face is to avoid putting an ice-bag or any heavy application on an eyelid that is swelling as a *relatively light pressure may shut off the blood supply and necrosis will result*

Infections

For infections hot applications (moist or dry) most frequently relieve the pain and localize the process Opposition in favor of cold will often be encountered and since neither process is very well under

tonic packs of sodium chloride, boric acid, magnesium sulphate, or any desired antiseptic may be used Then instead of being pulled off they may be soaked free in the bath each day and reapplied later

Quartz Light.—Quartz-light treatment of these areas may well be combined in this as in any method of treatment. General radiation two to four times a week will usually be ideal although heavier radiation of local areas of persistent infection may be indicated

Exercises and Occupational Therapy —General physical therapy in the form of active exercises of the hand arm or leg muscles is of great advantage Any occupational therapy, especially with children has frequently marked the turning point of recovery The outside limit of activity is encouraged, even if this is nothing more than the knitting of a wash cloth or the cutting out of paper figures The use of musical instruments or even encouragement to feed themselves may make marked improvement (Figs 7 8 and 11)

Skin Grafts

Preliminary Preparation.—The physical preparation of widely denuded areas for skin grafting is essentially as outlined under Extensive Burns For chronic ulceration of the legs, rest in bed for one to three weeks may be advisable, and may in itself be the main element in a successful skin graft. Added to this there may be elevation or elastic bandaging for the support of the blood column. If the patient remains ambulatory some type of hypertonic dressing plus a supportive dressing is necessary Quartz light used locally over infected surface areas may be of great benefit [1] (Figs. 12 and 13)

Fixation of Dressings.—One of the most essential factors in successful skin grafting is applying the dressing with the correct mechanical pressure on it and maintaining it in place. The routine use of damp marine sponges (or some other medium) for obtaining elastic pressure incorporated in the original dressing of a skin graft, is as important as any single step in the operation The sponge itself does not supply the pressure but must be held accurately in place and at accurate tension by the bandages [2, 3]

Joint movements about grafts must be restrained by bulky dressings or by wood or plaster splints.

After Care.—Good gentle mechanical cleansing is important from the start. If time can be taken for it, actinic radiation at the time of each dressing may have a beneficial effect on healing The dressing is removed and all grease is cleaned from the area. The graft and surrounding area are then exposed directly to the quartz light. Usually the first dosage is 1 minute at 36 inches. The time is increased 1 minute and the distance decreased 1 inch up to 10 minutes at 20 inches.

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For the contraction that occurs under some skin grafts and tends to wrinkle them, we have occasionally found good relief by the use of light exposures of radium preferably given as soon as the wrinkling becomes apparent.

X Ray and Radium Lesions

The underlying pathology is a destruction of the collagen and an endarteritis of the finer vessels This is followed by a telangiectasis of the capillaries which may later become thrombosed keratosis of the epithelium, and occasionally transition to carcinoma. Since the exciting cause is the x ray or radium ray it would seem inadvisable to employ sunlight quartz light or further x-ray or radium ray in the treatment of these lesions However all the above forms of radiation have been advised and the practice is mentioned here only to call attention to its apparent uselessness The only solution to the problem of relief of badly or widely involved areas is total destruction by electrocoagulation or electrodesiccation by the actual cautery or by sharp dissection It is preferable to excise wide areas and this usually calls for some method of surface repair such as the shifting of adjacent healthy tissue or the use of free skin grafts or pedicled flaps

Repair of Surface Losses of the Hands

The loss of surface covering of the hand results from innumerable types of accidents but most frequently from burns One of the most crippling deformities results from injury from household mangles in which there are both a severe burn and a crush Early determination of the extent and depth of destruction is very important in these cases and where there is any appreciable extent of skin loss steps should be taken immediately to clean the wounds and to cover the defects with tissue of suitable thickness If there is destruction of the full thickness over the dorsum of the hand and fingers and if some form of expectant treatment is instituted in which crusts form on the wound and slowly separate ultimate healing may occur by spontaneous epithelization However the attendant infection and scar tissue formation about the joint capsules and tendons will so limit motion that normal function may never be obtained. Losses on the palmar surface of the hands and fingers do not often result in such permanent damage because the heavy subcutaneous tissue protects the joint capsules and tendons to a marked extent. The surface scar may be extensive but usually when it is released the tendons will give and the joints will open.

Preoperative Period—Splinting —During the period of waiting for reconstructive operations correct splinting and dressing are important. Extreme secondary contractures in either flexion or extension

stood, arguments on both sides may be given for the use of one over the other As a general rule, heat is probably most effective and is most kindly received by the patient for swelling from infection, while cold is better for swelling from trauma.

For erysipelas and similar types of infection that occur about the head and face during the process of repair of a defect, hot hypertonic applications are used routinely X-ray radiation in the form of light exposures may be used and excellent results are obtained in many instances

Chronic furunculosis or pimple formation is a definite contraindication for the plastic repair of any defect because it is an expression of low resistance in general and because the organism being ready to contaminate any field, may set up an active infection in the operative field itself Along with other general treatment measures either x ray or actinic radiation will be found very useful in clearing up this skin condition

Scars

As soon as the wound has healed in some instances, active physical therapy may be started to relieve the scar defect Excellent results may be obtained by the use of actinic radiation, followed by heat (usually dry as from a large electric light bulb or an infra red baker) After this, prolonged gentle massage is given. Heat is applied over the scar for 5 to 10 min. Then a lubricant (cocoa butter, for example) is applied and the trained technician starts a gentle stroking massage. As the wound becomes older and therefore firmer the strength of the massage is increased and should consist of both stroking and kneading. The massage should last for at least 30 min. If possible it should be repeated daily for the first two weeks and then applied every other day until the scar has been loosened and its deforming appearance overcome, or until no further progress is made

Surface scars occurring in suture lines or around the edges of grafts present the greatest hindrance to acceptable surgical restorations about the face It seems that they occur most frequently where they are least desired. Plump or fat children or young adults are the most susceptible, probably because of tenseness and thinness of the skin from distention of the subcutaneous fat. Infection in the suture line during healing, cuts and incisions across the lines of skin tension and poor approximation are, of course contributing causes.

Of the many physical agents directed against these scars radium seems to offer the best help Capsules of 25 mg of the element with a screening of 1 mm. of silver and 1 mm. of rubber applied along the scar for one to one and one-half hours frequently suffice The dose may be repeated once or twice if it seems advisable

Deep scarring does not respond well or uniformly to radiation, and applying the rays through any considerable thickness of tissue to affect deep scarring is a questionable procedure.

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stood, arguments on both sides may be given for the use of one over the other As a general rule heat is probably most effective and is most kindly received by the patient for swelling from infection, while cold is better for swelling from trauma.

For erysipelas and similar types of infection that occur about the head and face during the process of repair of a defect, hot hypertonic applications are used routinely X-ray radiation in the form of light exposures may be used and excellent results are obtained in many instances

Chronic furunculosis or pimple formation is a definite contraindication for the plastic repair of any defect because it is an expression of low resistance in general and because the organism, being ready to contaminate any field, may set up an active infection in the operative field itself Along with other general treatment measures, either x ray or actinic radiation will be found very useful in clearing up this skin condition.

Scars

As soon as the wound has healed in some instances active physical therapy may be started to relieve the scar defect. Excellent results may be obtained by the use of actinic radiation followed by heat (usually dry as from a large electric light bulb or an infra red baker) After this prolonged gentle massage is given Heat is applied over the scar for 5 to 10 min. Then a lubricant (cocoa butter for example) is applied and the trained technician starts a gentle stroking massage. As the wound becomes older and therefore firmer the strength of the massage is increased and should consist of both stroking and kneading. The massage should last for at least 30 min If possible it should be repeated daily for the first two weeks and then applied every other day until the scar has been loosened and its deforming appearance overcome or until no further progress is made.

Surface scars occurring in suture lines or around the edges of grafts present the greatest hindrance to acceptable surgical restorations about the face It seems that they occur most frequently where they are least desired Plump or fat children or young adults are the most susceptible, probably because of tenseness and thinness of the skin from distention of the subcutaneous fat Infection in the suture line during healing, cuts and incisions across the lines of skin tension, and poor approximation are of course, contributing causes.

Of the many physical agents directed against these scars radium seems to offer the best help Capsules of 25 mg. of the element with a screening of 1 mm. of silver and 1 mm. of rubber applied along the scar for one to one and one-half hours frequently suffice. The dose may be repeated once or twice if it seems advisable.

Deep scarring does not respond well or uniformly to radiation and applying the rays through any considerable thickness of tissue to affect deep scarring is a questionable procedure

For the contraction that occurs under some skin grafts and tends to wrinkle them, we have occasionally found good relief by the use of light exposures of radium preferably given as soon as the wrinkling becomes apparent.

X Ray and Radium Lesions

The underlying pathology is a destruction of the collagen and an endarteritis of the finer vessels This is followed by a telangiectasis of the capillaries which may later become thrombosed keratosis of the epithelium, and occasionally transition to carcinoma Since the exciting cause is the x ray or radium ray it would seem inadvisable to employ sunlight quartz light, or further x ray or radium ray in the treatment of these lesions. However all the above forms of radiation have been advised and the practice is mentioned here only to call attention to its apparent uselessness The only solution to the problem of relief of badly or widely involved areas is total destruction by electrocoagulation or electrodesiccation by the actual cautery or by sharp dissection It is preferable to excise wide areas and this usually calls for some method of surface repair such as the shifting of adjacent healthy tissue or the use of free skin grafts or pedicled flaps

Repair of Surface Losses of the Hands

The loss of surface covering of the hand results from innumerable types of accidents but most frequently from burns. One of the most crippling deformities results from injury from household mangles in which there are both a severe burn and a crush Early determination of the extent and depth of destruction is very important in these cases and where there is any appreciable extent of skin loss steps should be taken immediately to clean the wounds and to cover the defects with tissue of suitable thickness If there is destruction of the full thickness over the dorsum of the hand and fingers and if some form of *expectant treatment is instituted in which crusts form* on the wound and slowly separate ultimate healing may occur by spontaneous epithelization However the attendant infection and scar tissue formation about the joint capsules and tendons will so limit motion that normal function may never be obtained Losses on the palmar surface of the hands and fingers do not often result in such permanent damage because the heavy subcutaneous tissue protects the joint capsules and tendons to a marked extent. The surface scar may be extensive but usually when it is released the tendons will give and the joints will open.

Preoperative Period—Splinting —During the period of waiting for reconstructive operations correct splinting and dressing are important. Extreme secondary contractures in either flexion or extension

deformities and even in subluxation of the phalangeal joints may be largely avoided by gentle dressing in simple splints with the fingers ex tended or flexed as indicated If there is loss between fingers they should be held apart with even a simple piece of gauze used as a splint. Too often where most of the skin of the hand has been lost (the "degloved hand" as used in English literature) the final result is a scarred mass with thin scar epithelium continuous over all the fingers and with function practically nil This same thing happens in losses in the cubital fossa and in the axilla where the forearm is allowed to attach itself to the arm, and the arm to the chest wall

Saline Bath —If the patient is given a warm saline bath and a small rubber ball or sponge to handle for one to three hours a day, he will probably greatly overcome the tendency to deformity As the wounds become clean gentle massage and passive motion may be added while the hand is in the warm saline soak

Postoperative Period.—After operation in which binding scars have been excised or released perhaps joint ligaments have been cut and there has been surface restoration of suitable thickness, a new drive for function must be made and physical therapy is often put to a severe test.

Splinting —Splinting is still imperative to overcome joint, joint capsule and tendon deformity The main criterion is whether the thumb can be apposed to the fingers, and the next is whether suitable flexion of the fingers for gripping can be established In practically all cases the wrist should be cocked up if there is any involvement around it. As a working basis, the splints employed by Drs. Kanavel Koch, and Mason may be taken as a standard

Massage.—Massage can usually be begun early and should be carried out intelligently over long periods of time Fifteen to thirty minutes once or twice each day may be used if the force is carefully graduated The massage may be given during periods of dry heat, or following hot wet baths and the working time each day may thus be reduced When joint motion is limited an important addition to simple massage is to move the joint through its full range of motion and to maintain it in its extreme flexion and extension with gentle force for 5 to 15 min. at a time Real pain should not be caused but the force should be stopped just as discomfort is noticed. Instead of being allowed to relax completely the joint should be maintained in this position and usually in a few moments some further slight relaxation may be obtained.

Exercises —Muscle-training exercises may be begun in the simple fashion of closing the hand on a rubber sponge or ball and activity may be increased rapidly

Joints and tendons in children respond rapidly and a normal child is likely to adopt the best possible activity if he is given the opportunity of interesting play (Fig 11)

Occupational Therapy —Occupational therapy by supplying the mechanical means and the trained instruction in gross and fine activities can frequently cause the patients to make rapid strides A general idea of the problem must of course be given to the therapist by the surgeon together with careful instruction as to the greatest activity desired. If the trained instructor adds her knowledge of diversion to the training better purposeful results may be expected and articles of real value may be made by even small children (Figs 7 and 8)

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CHAPTER THIRTEEN

PHYSICAL THERAPY IN AMPUTATIONS

C C Yount M D

In this chapter the amputation stump will be discussed as a functioning member primarily Surgical aspects will be considered only insofar as they have bearing on function In amputations of the lower extremity all stumps except certain partial foot amputations require a prosthesis The stump is a lever which swings the prosthesis in the act of walking and the efficiency of that lever depends upon many factors other than the mere surgical soundness of the end of the stump i e muscle power in the extremity condition of joints adjacent to the stump etc. Not only should a stump be so planned that its function will be as efficient as possible under the surgical condition demanding the amputation but all means of treatment should be utilized to improve and hasten its early functional use Certain forms of physical therapy are of great value in the preparation of the stump for early and efficient function

The need of physical therapy treatment is of course greater when healing is delayed on account of infection and other causes in which case the prolonged inactivity leads to atrophy of the extremity and a tendency to the development of joint contractures

The stump end (end of stump to first joint) is the weight-bearing portion of the stump in below knee amputation and the extremity proximal to the stump end must function as the propelling force for the stump end as well as for the prosthesis The latter averages about five and one-half pounds in weight. It is quite evident, therefore that the proximal part of the extremity must have normal or better above normal power and range of movement, whereas the stump end must inevitably undergo pressure atrophy and must develop weight bearing tolerance To state it briefly then the aim of physical therapy is to hasten the inevitable shrinkage to develop weight-bearing tolerance in the stump end at the same time preventing atrophy and deformity and to develop power in the proximal part of the extremity

Stumps That Heal Without Complications

In amputations of the lower extremity in which primary healing has taken place and in which there have been no complications of any kind, actual functional use of the stump can be safely started with a temporary prosthesis from four to six weeks after healing

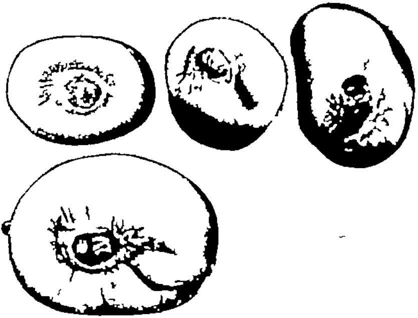

FIG. 1.—Unhealed stumps with terminal scars and edematous soft parts.

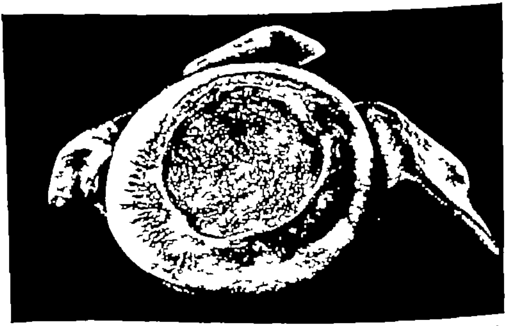

FIG. 2.—Sagittal thigh amputation. Large terminal, infected unhealed area, adjacent soft parts edematous. Notice traction straps turned back.

of the wound is complete Considerable difficulty in having this part of the program of treatment carried out will be encountered if the surgeon does not have facilities at his disposal for supplying the temporary prosthesis Most commercial limb-fitters will instruct the patient to wait until the stump has shrunk before fitting a finished appliance It is obvious that during the period of stump shrinkage atrophy is also taking place in the relatively inactive extremity, proximal to the stump end.

The following routine should be followed in this group of cases Elevate the stump immediately after amputation to lessen swelling and the possibility of hemorrhage. Do not disturb the elevated position for about four days On the fifth day remove the stump from the elevated position and passively move the adjacent joints Repeat this each day until the wound is healed After healing is complete, have the patient move all joints in the stump extremity through their full range once daily Apply a flannelette or some type of elastic bandage so as to exert gentle compression of the stump in order to prevent swelling and edema and to begin the process of shrinking which later must be more vigorously pushed.

Walking with crutches should be started as soon as the general condition of the patient and the surgical condition of the wound will permit. Massage of the unaffected extremity is not necessary in this group but massage of the stump leg should be started about the tenth day and should be continued daily until the temporary prosthesis is fitted This massage should be nutritional in type (see Chap 14) the aim being to maintain muscle tone and to prevent the atrophy of disuse. There is little need for massage in this group after functional use of the stump leg is started.

Compression bandaging of the stump should be continued until pressure atrophy is well advanced—i.e. until the stump is ready for a final prosthesis (Figs. 17 18 19) Bandaging at first should be done by the surgeon or an instructed attendant. A flannelette or other type of elastic bandage should be applied in the following manner First, several folds of the bandage should be pressed over the end of the stump so that slight compression of the end and sides will result. Then circular bandaging should be begun, starting at the very end and gradually compressing the stump circularly as succeeding folds of the bandage are moved proximally The compression bandage should not be carried beyond the first joint furthermore, it should not impede free and full movement of the joint. After the bandage is applied a tight woolen stump sock should be pulled over the bandaged stump to prevent disarrangement of the bandage The *amputé* himself should be instructed in bandaging his stump After an appliance has been fitted and the *amputé* has been instructed in the proper use of his appliance, there is little need for physical therapy as functional use will soon complete the atrophy of the stump end and will quickly develop the proximal part of the stump

Infected Amputations

Cases in which healing has been delayed, because of infection or for other reasons, offer conditions which demand early coördination of surgery and physical therapy For this reason it seems advisable to summarize stump pathology and surgical treatment of the infected stump in order to point out the essential physical therapy which should be administered in various forms during the progress of surgical treatment.

Primary Sagittal Amputation.—Experience gained in the war shows that primary amputation in the presence of severe infection at the site of injury, leaving the end of the stump wide open for drainage, should also be done in civil life under similar conditions. In wounds in which there is irregular laceration of the tissue the amputation need not be done exactly sagittally but may be done quite irregularly merely by removing all tissue which seems to be definitely avascularized For instance if one side of the leg were shattered leaving a long flap of viable tissue on the opposite side, it would be well to save an ample part of the viable flap, even though the amputation line would be quite irregular In all cases, as much bone length as possible should be saved at the primary amputation (Fig. 10)

Pathology Referable to Bone.—Osteomyelitis —The process of sequestration and involucralization with associated low-grade infection of the adjacent parts does not differ materially from osteomyelitis under other conditions, except that drainage is, perhaps, more thorough because it is terminal (Figs 3-6)

This terminal osteomyelitis is one of the chief causes of long-delayed healing, and requires roentgenographic study and special treatment before secondary final plastic operations can be successfully done.

The most common type of sequestrum seen is ring-shaped, usually about one and one-half centimeters in thickness. It is occasionally encroached upon and often more or less concealed by excessive bone production extending down from the bone cortex. In some instances it is seen to be practically encapsulated by new bone formation with a small sinus leading through the latter In such cases long-delayed healing is to be expected, so that it is advisable to remove sufficient of the encircling new bone to permit the soft parts to fall in and obliterate the dead space

Excessive terminal bone production in guillotined stumps is the rule. The most common form seen is an irregular mushroom formation with a tendency to spurs on the inner aspect of the femur Occasionally sharp exostoses often sharp enough and long enough to cause sufficient pain to warrant their removal are seen It is well not to interfere with the terminal bony production unless sequestra are embedded or concealed in it

Interosseous bony union occurs both in the forearm and leg In the former, operative interference is indicated only if the forearm stump is long enough to preserve pronation and supination Treatment consists in removing the connecting bony overgrowth and the




FIG. 3—Large spur extending int dduct intermuscular plane from short femoral stump

FIG. 4—Small spurs projecting from both tibia and fibula. This type of spur probably due to stripping up and shredding of periosteum.

FIG. 5—Smooth healing of leg amputation without any bony change. (From the U S General Hospital No 6 Fort Des Moines, Iowa)

FIG. 6—Arm stump, showing marked rarefication of bone from prolonged disuse Healed without infection.

interposition of muscle In the leg this condition is helpful rather than detrimental

Inequality in the lengths of the bones in amputations of the forearm and leg occasionally demands correction In leg amputations it is preferable, for prosthetic reasons to have the fibula approximately two centimeters shorter than the tibia. In children one should always amputate the fibula from two to four centimeters above the tibia, because of the tendency of the fibula to grow at a greater rate from the upper epiphysis than the tibia. In certain short below knee stumps it is possible at the primary amputation to save several inches of fibula but a much smaller amount of tibia. In this case, of course, there should be no sacrifice of fibula

Pathology Referable to Soft Parts.—Redundant soft parts are occasionally seen. This is usually due to late necrosis of bone or to extensive comminution of bone without equal damage to the soft parts In the latter instance it is best to save all viable soft parts at the primary amputation as thereby the later plastic surgery may be greatly facilitated. Except in certain instances, where there has been extensive comminution of bone redundant soft parts are *prima facie* evidence that more bone has been sacrificed than was necessary The secondary removal of soft parts for surgical or prosthetic reasons should not be decided upon until the necessity for and the possibility of, utilizing them in connection with osteoplastic methods to increase the length of the stump have been considered Bone grafting to increase the length of the stump is a well recognized and valuable procedure and is especially applicable to short below knee stumps.

Tender nerve ends are seen most frequently in amputations of the upper extremity and occasionally in those of the lower extremity They seldom make themselves manifest until an appliance has been worn so that in the treatment of unhealed stumps it is safest to assume that every nerve which is palpable may give trouble, and its treatment is indicated at the time of secondary plastic procedure. Simple high division after crushing and ligature seems to give results equally as good as those obtained with more elaborate neuroplastic methods

Preoperative and Nonoperative Treatment of Infected Stumps

In a preliminary report of experiences in treating the first five hundred amputations at Walter Reed Hospital the author advocated an ultraconservative policy in the surgical treatment of unhealed stumps. It seemed at that time that, by the use of skin traction and other non operative measures healing could be obtained in a reasonable time, and that secondary operative surgery of the stump could be dispensed with in the majority of cases. Subsequent experience showed that it was possible to obtain complete healing in guillotined and other in

fected stumps, but that a very long time was required and that the resulting scar was not sufficiently tolerant to the usual traumas of an appliance to be practical. It was also found that many either actually required an alteration in site or that a limited amount of bone could be removed without damaging the stump from a functional viewpoint so that, finally, plastic methods designed to obtain a firm closure with freely movable skin were employed usually before cicatrization was complete.

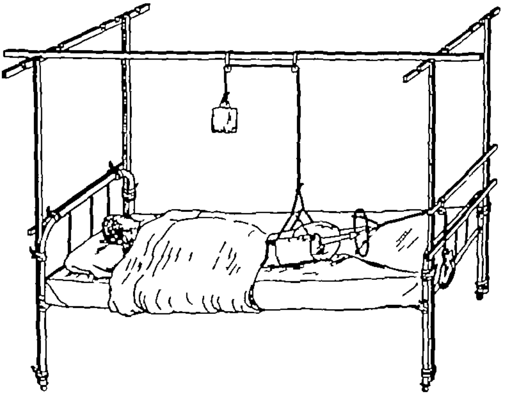

FIG. 7.—Stump traction in recumbency. The adhesive straps which extend from the stump to the ring should be so placed that the flaps will tend to coapt when traction is made upon the skin. The pulley should be arranged so that it can be lowered and raised at will, in order gradually to combat flexion deformity. The foot of the bed should be raised six inches. The amount of weight can best be determined by observing the pull on the stump after weight is applied. Stump traction should not be so strong that redundancy is created at the end. In case stump traction is desired with the patient ambulatory a short Thomas splint may be substituted for the apparatus shown in this picture.

Preoperative Routine.—SURGICAL REST.—The importance of surgical rest in the treatment of large infected stump wounds cannot be too strongly emphasized. Nothing is gained in hastening prosthetic treatment to the point of applying temporary prostheses before the stump can be considered surgically sound. In the majority of cases it is best to treat all cases requiring secondary surgical procedures in recumbency until wounds are in the desired condition for operation. It has been noted repeatedly that wounds which remained practically

stationary under ambulatory treatment would promptly heal in recumbency

SKIN TRACTION —Skin traction is used routinely both in recumbent (Fig. 7) and ambulatory treatment (Fig 9) In the former case, direct extension is accomplished by means of adhesive strapping, or with a pulley and weights and in the latter, by means of counter extension with a modified Thomas splint.

Traction is of course most effective if applied immediately after amputation Its effect then is actually to reduce the extent of the uncovered area. If it has not been applied early, and if the skin has

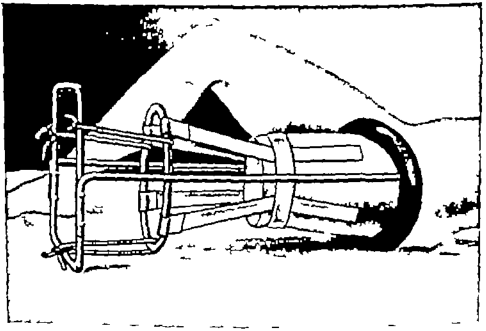

FIG. 8.—Stump extension with a modified Thomas knee splint. A Thomas knee splint is cut down and a 9-in. square riveted to the side bars 11 in. beyond the end of the stump An 8-in. circle of aluminum is attached by gauze and glue to the skin of the stump so as to be 6 in distal to the cut surface Extension is made from the ring to the square by either tapes or rubber bands. The square acts as a pedestal and also serves for the attachment of the extensions. (Adapted from Sinclair)

been allowed to retract and to become adherent to the edges of the unhealed area traction does not tend to reduce the unhealed area materially but it relieves tension at the edges of the ulcer thus favoring healing It is particularly helpful in subsequent plastic operations because it renders the skin more redundant. In some cases in which there is wide retraction of the skin in short stumps it seems best to dissect the skin free and then apply traction for a time before attempting a final plastic closure. The influence of stump traction in the prevention of joint contractures is obvious.

Wound Antisepsis.—The Carrel Dakin routine treatment should be used in all infected stumps as long as the unhealed area is large, concave and discharging pus freely

Massage.—Massage of the terminal part of the stump is beneficial in several ways In healed stumps with small scar areas adherent to the bone much can be accomplished toward loosening the scar and improving its circulation and thus increasing its tolerance to trauma In unhealed stumps massage of the skin adjacent to the scar area assists in removing edema and generally improving the circulation as well as in rendering the skin free and more redundant preparatory to the final plastic surgery

FIG. 9—Ambulatory traction fo below knee stump

Attention to Adjacent Joints.—At each dressing the stump should be moved fully in the opposite direction to that in which a contracture is most likely to develop Insofar as it is possible the recumbent position of the patient and the adjustment of traction should be such that the usual contractures will tend to be prevented. (Special treatment of each joint will be mentioned in the discussion of Amputations and Their Prosthetic Requirements.)

Secondary Stump Surgery—Attempts to perform final plastic closures of infected or guillotined stumps soon after the injury result in a high percentage of failures The most important factors in the failures are (1) the poor general condition of the patient following the more or less severe trauma and the subsequent emergency operative and postoperative treatment, and (2) latent infection, which is present not only in the terminal granulating area, and, in many cases, in the terminal portion of the bone but also in the lymphatic channels and lymph nodes, for a considerable distance proximal to the unhealed area.

It is not justifiable to attempt plastic closures or reamputations adjacent to the unhealed area until at least five or six months have elapsed from the time of the original injury An attempt was made, in army hospitals during the war to establish definite preoperative indications by bacterial counts from the wound surface but it was apparent that this method of control was not reliable as it gave no indication of the extent of latent infection in the lymphatic channels further up the limb It was found better to depend upon observations referable to the clinical appearance of the stump and the general condition of the patient.

As long as a stump remains swollen, boggy, and edematous, it will be found that there is latent infection present which will defeat attempts at plastic closure (Figs 1 and 2) The disappearance of the edema is usually coincident with the improvement in the general condition of the patient and the local appearance of the unhealed area. Final closure should not be attempted until the skin and subcutaneous tissue are soft dry, wrinkled freely movable, and absolutely free from streptococcus and the field count is reasonably low for other less virulent pyogenic organisms

Operative Treatment of Unhealed Cases

Group I.—In this group are stumps in which a limited amount of bone may be removed without diminishing the ultimate functional value of the stump

The question of bone length requires careful consideration in every case and there are times when it is justifiable to preserve it by sacrificing ideal conditions in the soft parts. But, on the other hand in perhaps the majority of the sagittal amputations, little is lost in ultimate function by removing a limited amount of bone and much may be gained by the additional freedom allowed to eradicate more thoroughly the potential latent pathology in the terminal portion of the infected stump Before attempting final plastic closure in cases in this group all indications previously pointed out regarding the proper time to operate should be present, except that the actual size of the unhealed area can be disregarded.

Method of Operating in Group I—The unhealed area and the scar are completely covered with a gauze sponge which has been saturated with tincture of iodine. Incision is now made in healthy skin one-half centimeter from the edge of the scar The incision should follow the general contour of the scar area and no attempt should be made to form specially designed flaps The distal skin edge is clipped to the iodized gauze as the incision is being made, thus completely isolating the terminal infected area The skin and scar are then dissected distally and separated from the muscle at the place where the muscles are attached to the bone Usually this will be above the area of new bone production and well away from the unhealed area usually one or one and one-half inches Incise the periosteum just within the area of fibrous tissue which extends a short distance distal to the actual muscle fibers Saw the bone at this point. If the preoperative treatment has been properly carried out and the scar area is not excessive, it will now be possible by careful disposition of the skin, to cover the end completely If it is found that the available skin is not sufficient, additional bone or muscle may be removed. It is better to avoid cutting through the muscles and deep vessels The nerves are found usually by palpation and should be pulled down and severed through a small longitudinal incision in the muscles The wound should be drained for 48 hours through a posterior stab wound. This type of drainage is preferable because First it gives the best drainage, being dependent and second in the event primary union is not obtained sufficient drainage is afforded through the posterior opening to prevent the incision line from separating Primary union in the incision line is often obtained and maintained in the presence of profuse purulent discharge which is satisfactorily taken care of through the posterior drainage incision

Group II—In this group are stumps which are already too short and which will not permit additional sacrifice of bone

It is imperative that at least six to eight months have elapsed since the initial injury and that in addition to the preoperative requirements already enumerated the wound be completely cicatrized or that the unhealed area be very small and practically sterile.

Method of Operating in Group II—The scar should be completely removed The bone should not be disturbed unless there are exostoses which are likely to give trouble Palpable nerves should be treated as described in Group I The aim of the operation is of course, to cover the stump completely with healthy freely movable skin. This is practically never possible without special plastic procedures The short, below-the-knee stump is the most common example of this group The limited amount of skin may be made more accessible in several ways (1) by removing the fibula (2) by removing the major portion of the muscles of the calf of the leg A triangular section with

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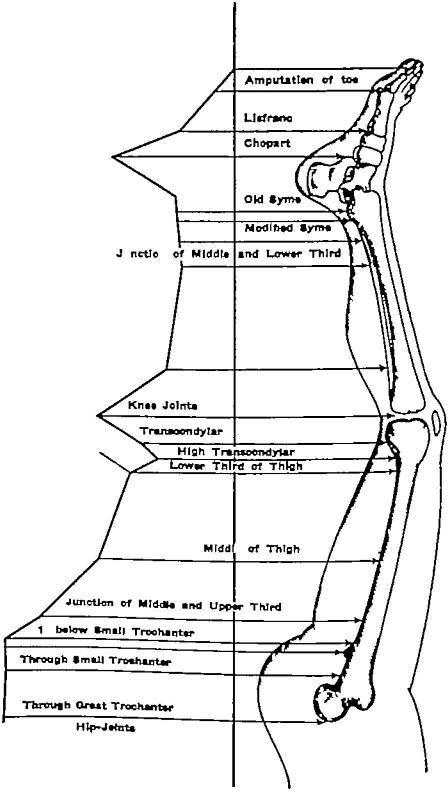


FIG. 10.—Graphic representation of the relative functional value at different levels of bone section. The curve falls rapidly in partial amputation of the foot. The bottom is at Chopart site. It rises sharply to the Syme level and falls away in the lower third. It then gradually descends as bone length diminishes from the lower third up to within three inches f the knee joint. It rises to the point f highest efficiency at the transcondylar site, then falls way gradually in the thigh up to within three inches of the joint where the bottom f the curve is reached and maintained, including all amputations up to disarticulation.

the base external gives the best skin mobilization. The muscular tissue directly attached to the bone should not be disturbed and care should be taken to leave sufficient blood supply (3) by using the following methods of skin plastic procedures which have been found successful

1 Double lateral pedicle
2 Double oval swing
3 Single oval swing
4. Distal pedicle transplant

Group III —This group includes those cases in which sagittal amputations had been done at a site considerably distal to the ultimate secondary site to be selected Amputation through the ankle joint is an example. In this case the Syme amputation could not be considered, as sufficient soft parts are not available so that the next choice of site would be through the junction of the middle and lower third of the leg Other examples would be sagittal amputations one-half inch below the knee joint requiring a formal transcondylar amputation

In this group it is possible largely to disregard pathology referable to the terminal part of the stump and to proceed with the final amputation much earlier than in the other groups In all cases however it is advisable to adhere strictly to the rules regarding delay until the general condition is sufficiently improved to withstand a major surgical procedure and to those regarding edema of the soft parts and associated lymphangitis and lymphadenitis. The treatment in this group is formal reamputation

Operative Treatment in Group III —A reamputation is equivalent practically to a primary amputation under ideal conditions and necessarily involves careful consideration regarding the site and its influence upon the ultimate functional result. The value of a stump in terms of function can be correctly estimated only when the stump and its prosthesis are considered as a complete functioning unit. It follows then, that in order to choose the proper site one must consider carefully the comparative value of prosthetized stumps

Amputations and Their Prosthetic Requirements

Lower Extremities.—Partial Amputations of Foot —Amputation of toes, metatarsophalangeal amputations and transmetatarsal amputations result in good function All the length possible should be saved. It is a mistake to do a textbook amputation if more bone can be saved than is specified in the classical type of amputation. All bone length possible should be saved in the metatarsus It is justifiable to attempt to preserve bone length in the metatarsus at the expense of perfect skin covering and immediate sound healing All such cases require a distal pedicle transplant later but the delay and the extra

surgery necessary are well compensated for in function. A scar on the foot healed by granulation, directly overlying bone, will inevitably ulcerate and cause intermittent disability Every effort should be made to obtain a dorsal linear scar, with the ends of the bones well covered with a plantar flap The use of the distal pedicle transplant will obviate the necessity of reamputating partial foot stumps with an intolerant scar

Lisfranc's Amputation—Lisfranc's amputation gives reasonably good function only in case dorsal flexion of the foot is preserved by anchoring the dorsal flexors of the toes to the ends of the bones. The same general surgical considerations apply here as described for metatarsal amputations The only appliance necessary for this, as well as

FIG. 1 —Chopart stump, showing usual deformity (Huggins.)

for the former is a filler for the toe of the boot and a steel inset in the sole to prevent turning up of the toe.

Transtarsal Amputation—Transtarsal amputation distal to Chopart's site seems preferable to a formal Chopart's amputation, as proper balance of the dorsal and plantar flexors of the foot is better preserved However the same prosthetic objections apply to this amputation as to the Chopart.

Chopart's Amputation—Chopart's or mediotarsal amputation usually results in poor function for surgical as well as for prosthetic reasons (Fig 11)

(*a*) The type of injury requiring a Chopart stump seldom leaves sufficient plantar flap to permit the scar to be placed well on the dorsal surface

(*b*) Equinus deformity of the stump eventually develops in spite of efforts to preserve foot balance by tenoplastic procedures As equinus develops the scar which is usually terminal and poorly vascularized, is pressed upon and end bearing the greatest asset of this stump must be forfeited

The stump is too short properly to anchor the necessary fill in the forefoot, so that constant friction between the toe fill and the end of the stump takes place usually resulting in ulceration and consequent disability Lack of stability in the toe of the appliance prevents the necessary forward thrust in walking so that slight limp is invariably present. In many Chopart stumps it is necessary to anchor the forefoot by extending a steel rod to the ankle joint and connecting this by a joint to a steel upright which is laced to the leg This appliance requires a special shoe with a very unsightly ankle

The percentage of surgical successes in Chopart stumps is so low and the prosthetic difficulties so great that it is not a justifiable amputation unless it is intended that a simple elephant boot be worn continually instead of the articulated appliance. This point is mentioned because there are undoubtedly cases in which occupational considerations should predominate over the esthetic.

The importance of preserving muscle balance in partial foot amputations requires special attention A plaster cast should be applied with the foot at right angles in slight inversion. The cast should be bisected so that it can be removed and replaced easily Passive and active movement should be started as soon as healing is complete. The dorsal part of the cast may be used as a night splint for several weeks during which time massage of the leg muscles is being carried out.

Pirogoff's Osteoplastic Amputation —The added risk of an osteoplastic procedure is not compensated for in any way as the per cent of total end bearing in the Syme amputation is quite as high as in the Pirogoff The added length in the Pirogoff requires that the other shoe be raised at least an inch to make up for the space required for the ankle movement in the appliance. This amputation is not recommended

Syme Amputation —The chief advantages noted in the perfect Syme amputation are that it is total end bearing and that the length of the limb is approximately preserved so that the patient can walk in the nude without his appliance and that either the straight boot or the appliance with an articulated foot can be worn with reasonably good function

Unfortunately the per cent of perfect Syme stumps is not high. Failure is usually attributed to one or more of the following causes sloughing of the plantar flap due to cutting the pedicle too narrow lateral displacement of the flap sawing of the bones at a right angle

to the terminal axis of the tibia, rather than at a right angle to the long axis of the leg making the bone section too near the joint to allow space for the mechanism of the artificial ankle.

Functionally, a perfect total end bearing Syme is a satisfactory stump The choice between this amputation and one at the ideal site in the leg involves an analysis of the occupation and habits of the patient A laborer is better satisfied with the Syme amputation because he can wear a straight, nonarticulated boot during the working hours, and he is less likely to be dissatisfied with the bulky, unsightly ankle mechanism when dressed up than a professional man, for example would be. In women leg amputation is preferable to the Syme for esthetic reasons.

Amputations of Leg.—*Lower Third*—Nothing is gained by the additional bone length in the lower third of the leg as excessively long leg stumps interfere with proper shaping of the ankle portion of the artificial leg and may actually interfere with the ankle mechanism. Poor vascularity is the rule in the lower third of the leg. This results in poor or delayed healing or in ulceration later in life.

Junction of Middle and Lower Third—Amputation at the junction of the middle and lower third of the leg has proved to be the preferable site in the leg The essential points in technic are (1) long anterior and short posterior flaps the scar line being posteroterminal (2) suture of a thin flap of muscle and fascia over the bone ends to prevent adherence of the skin to bone, (3) fibula divided one-half inch higher than the tibia (4) beveling of the tibial crest (5) drainage when necessary through a small stab wound in the middle of the posterior flap

The appliance for this amputation is simple, durable and shapely If the fitting is proper disability is scarcely discernible. Stump tolerance to the appliance is quickly acquired and the functional result is very gratifying to all concerned.

In amputations of the leg above this ideal level, every effort should be made to preserve all bone length possible When the amount of bone length that can be preserved with good soft part coverings is three inches or less it is justifiable to sacrifice ideal conditions as regards the soft parts if bone length can thereby be increased. It was generally considered early in the last war that it was not justifiable to attempt to amputate below the knee if the amount of bone length possible to be saved was less than three inches. Subsequent surgical and prosthetic developments warrant a revision of this opinion In these cases the leverage may be increased to the point of utility by removing the fibula cutting away practically all of the muscular tissue on the back of the stump and severing the inner hamstring. Special study and experimentation in the prosthetic treatment of short stumps carried out at various clinics gives promise of increasing the functional utility of stumps of not less than two inches in length, so

that it seems best to defer reamputation at a higher level until surgical attempts to increase bone length or to increase leverage by other methods have failed

The prevention of knee flexion contractures requires special attention in short below knee stumps. In addition to the usual measures the following procedures are necessary in very short stumps (*a*) Muscle or fascial suture over the bone end should be done with the

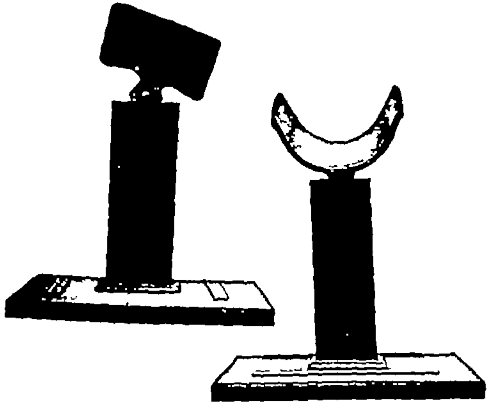


Fig. 12—A simple support or leg rest used to support the leg in below knee amputations. The support on which the leg rests is made of heavy metal covered with leather and is attached by joint to a wooden upright The wooden upright is supported in a hollow built-up wooden block which is secured to a wooden base. The support rests on the table on which the patient lies and is covered with sterile draperies before the sterilized leg is placed on it. It is placed under the leg, just below the knee joint, holding the leg extended, away from the table and is accessible on all sides. It may be placed higher up behind the knee in short below-knee stumps.

knee in full extension (most amputations below the knee are done with the knee flexed on a sand bag or stump rest (Fig 12)) (*b*) The biceps should be cut or better stripped up subperiosteally (*c*) A cast or posterior splint or traction should be applied until healing is complete and muscle balance is reestablished.

Amputations of Thigh —If it is not possible to amputate through the leg two inches from the knee joint (bone length), the next best

site is the high transcondylar This excludes knee-joint amputations, all osteoplastic amputations at or immediately above the knee joint, and low transcondylar amputations All of these are too long to allow the use of the standard artificial knee action and require a cumbersome and faulty mechanism outside the clublike stump Osteoplastic amputation (Stokes-Gritti) offers nothing in function superior to the high transcondylar to compensate for a rather high per cent of surgical failures and the prosthetic difficulties already mentioned In the high transcondylar amputation, the bone section is made at the point where the condyles begin to merge with the shaft. It is important to keep within the spongy bone below the beginning of the medullary cavity proper A long anterior flap of skin and quadriceps tendon is used. The scar is placed well to the posterior, away from the end-bearing surface Surgical failures are few, and total end bearing results in practically all cases Ample space is left to place the standard artificial knee action in the proper place.

Above the site for the high transcondylar amputation every effort should be made to save all bone length possible to a point two inches below the lesser trochanter All stumps having bone length of from two to four inches below the lesser trochanter require a pelvic band. This is an objectionable feature so that a special effort should always be made to preserve more than four inches, if possible A stump having bone length of less than two inches below the lesser trochanter does not have sufficient leverage to operate the thigh appliance on account of the disposition of the soft parts adjacent to the joint. The only choice then is to give a stump suitable for the so-called hip-joint appliance.

From a prosthetic and functional viewpoint the classical disarticulation at the hip is not preferable to amputation through the neck. The latter is much more quickly and easily performed. The mortality is lower and the resulting stump is better adapted for the fitting of an appliance. Unless there are definite pathologic reasons for complete disarticulation, as in new growths, amputation through the neck is preferable.

Contractures —In the short thigh stump contractures will develop unless preventive measures are instituted immediately after amputation The usual deformity is flexion and abduction. This deformity interferes markedly with good functional use of an appliance because it is necessary to throw the lumbar spine into marked lordosis in order to put the artificial foot squarely on the ground.

The following measures are effective in preventing this deformity

(*a*) Surgery The anterior and posterior groups of muscles should be sutured together and the fascia lata should be sutured to the adductor group This aids in preserving balance between the abductors and adductors and gives a more effective terminal attachment for the gluteus maximus, part of which is inserted into the fascia lata thereby increasing its mechanical advantage and enabling it to establish at least partial

FIGS. 13, 14, 15.—Stump drill. During the World War when groups of amputations were being cared for stump drill was found to be beneficial for increasing the range of motion and developing muscle power

balance with the strong iliopsoas which has been undisturbed at its relatively high insertion into the lesser trochanter

(*b*) Physical therapy As soon after the operation as the general condition of the patient will permit, he should be turned face down for at least one hour each day with a sand bag or hard pillow under the end of the stump which is forced into hyperextension. If this is not possible, stump traction should be applied in such a manner that extension of the hip joint will be maintained. After the stump is healed passive and active movements in the direction of extension and adduction should be done at the massage period and at other definite periods (Figs 13 16) daily until the stump is being used functionally

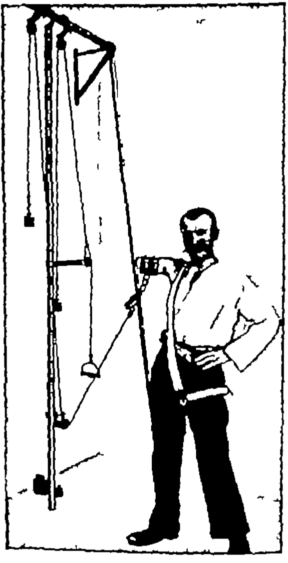
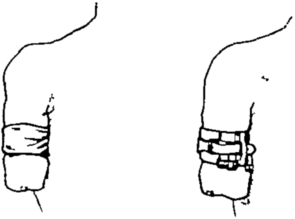


FIG. 16.—Numerous types of mechanotherapy to develop the musculature of short-arm stumps may be devised This illustration shows a simple type which is practical and was found useful.

The correction of long-standing flexion abduction contractures is best accomplished by surgery rather than by physical therapy alone Division of the fascia lata, followed by vigorous stretching manually and by mechanotherapy apparatus will correct moderate degrees of flexion. In the more persistent ones Scutter operation for hip flexion should be done It will seldom be necessary to free the attachment of the iliopsoas as the deformity is usually not a true flexion contracture.



FIGS. 17, 18, 19.—End of stump rendered clublike by the use of a constricting band. The clubbed end facilitates the attachment f apparatus. This is very useful in work appliances.

Upper Extremity —The rôle of the appliance in the functional utility of stumps of the upper extremity is considerably less important than in the lower extremity In fact, it is debatable whether in the

case of single amputations of the upper extremity appliances are of sufficient value to constitute a deciding factor in the selection of site. The patient who has lost an arm is eager for his appliance (1) because he wants to mask his disability, and (2) because he hopes it will be functionally useful. To his great disappointment, he soon realizes that it is, indeed, a poor substitute for either purpose. Approximately 60 per cent of the individuals who have suffered the loss of a single arm do not find existing prostheses sufficiently useful to compensate for the inconvenience of wearing them. The exception is that they wear them occasionally for esthetic purposes. The following conclusions regarding sites are based upon the use of American prostheses, and do not involve a consideration of surgical and prosthetic experimental work carried out in certain American and various foreign clinics since 1921 as opportunity for exhaustive study and evaluation of the results has

FIG. 20.—Radical surgical procedures are justified in attempting to restore the prehensile function to the hand. This shows a successful transplant of a part of the great toe to replace the thumb.

not been possible. (In 1920-21 the author visited all important amputation centers in England, France, Germany, Austria, and Italy under the auspices of the American Red Cross in order to observe and attempt an evaluation of the various methods of treatment developed during and after the war. Official reports of this study are available in the files of the American Red Cross in Washington.)

AMPUTATION IN HAND.—In primary surgery immediately following the trauma nothing more should be done than débridement, trimming the devitalized tissues and establishing thorough drainage, the question of site being totally disregarded. The prevention of contractures of the fingers by proper splinting demands special attention from the beginning.

In the secondary surgery of the hand, radical alteration in the site of amputation is seldom advisable The usual conditions demanding treatment are sluggish unhealed areas associated with localized osteomyelitis or tender and adherent scars with tendency to deformity especially when on the flexor surface of the joints The latter condition usually demands special plastic procedures in order that the scar may be displaced by freely movable tolerant skin The distal pedicle transplant gives the best results where it is important that no bone be sacrificed. Usually a portion of a phalanx of any of the fingers except the

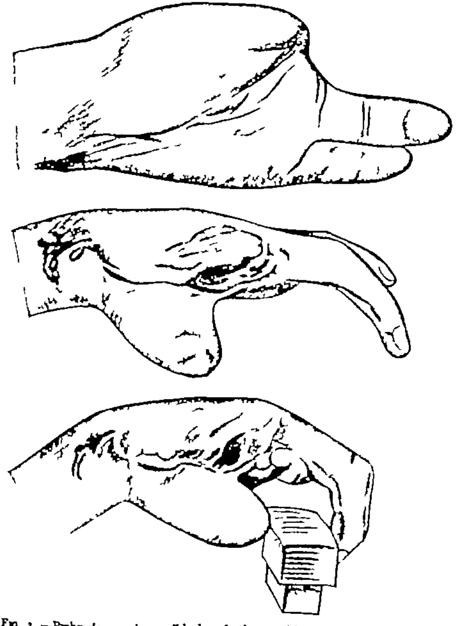


FIG. 2 —Prehension made possible by plastic reposition of metacarpus of thumb

index and the thumb, can be sacrificed without serious functional damage in order to obtain good soft-part covering (Fig 20)

The loss of the thumb or any part of it constitutes a serious disability A badly-damaged thumb, with loss of muscular power or ankylosis, or both, is preferable to any mechanical substitute. Heroic efforts at reconstruction of the thumb are justifiable (Fig. 21)

Prostheses for amputation of individual digits are seldom useful, except for the thumb They are most useful if the thumb is amputated or if all except the thumb are gone, as apposition is made possible by the prosthesis in either case. If a sufficient part of any of the fingers remains to make active apposition possible, a prosthesis is seldom worn except for esthetic reasons

Transcarpal Amputation—Transcarpal amputation is preferable to amputation at the wrist even though there is an adherent terminal scar The latter can be repaired by distal, pedicle skin transplant.

Wrist joint amputation is distinctly preferable to amputation higher up, as pronation and supination are better preserved, and the fitting of a hand or work appliance is facilitated by the more or less clublike end of the stump, which permits the elimination of much attachment harness

Amputation in Forearm.—Amputation in the forearm should be done as low down as possible. In the lower third circulation is often poor, but usually not troublesome enough to warrant amputation higher up solely on this account. Primary amputation should seldom be done higher up for this reason and reamputation should not be considered unless all efforts to improve the circulation have failed. The importance of preserving pronation and supination warrants special attention to surgical details i e. careful treatment of the periosteum to avoid shredding and consequent overproduction of bone, and the interposition of muscle to prevent bony bridging.

No matter how short a forearm stump may be it should not be sacrificed, as in the majority of cases a forearm stump is more useful without a prosthesis than an upper arm stump either with or without an appliance (Figs 22 25) Forearm stumps should never be shortened to correct inequality in the length of the bones Tender scars or objectionable scars should not be corrected for any reason by the sacrifice of bone but by plastic methods involving the soft parts only The presence of redundant soft parts is an indication for plastic methods to increase length rather than to remove redundancy

Amputation in Upper Arm.—Transarticular and transcondylar amputations are generally considered objectionable from the standpoint of existing prostheses because the fitting is difficult and there is inconvenience to the patient in applying and removing the apparatus. Moreover the artificial joint must be placed lower than on the normal arm. Experience shows however that in single amputations, less than

20 per cent of upper arm *amputés* wear appliances Of these, it is reasonably safe to assume that the majority are those wearing a practical (work) appliance rather than an esthetic one The newer practical appliances are more securely fitted with less harness if the bony prominence of the condyles is present so that before deciding upon the sacrifice of the condyles a careful analysis of the requirements of each individual case is necessary Above this level all bone length possible should be saved.

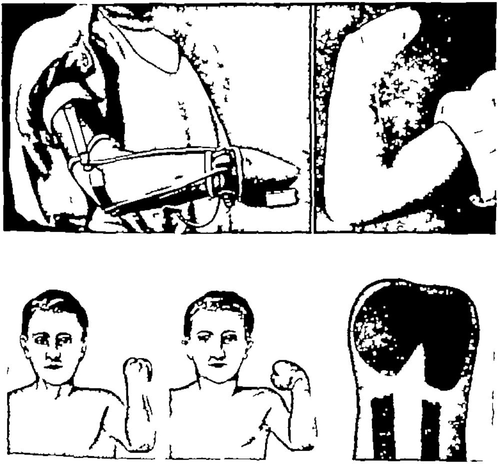


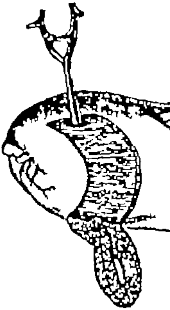
Fig. 3 15—Plastic pseudarthrosis club moto Valuable in work appliances.

Cinematization of Amputation Stumps

In July 1918 the report of a special committee directed to investigate the question of cinematization was available to those engaged in amputation work. The conclusions of this committee were, briefly that cinematization could not be recommended except as an experimental procedure because it was still in the trial stage, and that it should not be attempted unless adequate facilities were available for pursuing the

experimental prosthetic work necessarily associated with it. Three cases were cared for in the base hospitals in the United States and two patients with cinematized stumps were returned from overseas. In none of these cases was the final functional result a distinct improvement over that obtained with the usual methods Two were failures and required excision of the tunnels Lack of success was due to the failure of coördination of the surgical physical therapy, and prosthetic treatment, to the frequent transfer of patients, and perhaps, in a measure to the breaks in follow-up coincident with frequent changes in personnel after the Armistice

The admitted functional deficiency of all prostheses for the upper extremity stimulated surgeons, before and during the war to try to utilize muscle power in the stump by connecting it more effectively to the prosthesis, so that the muscle power could be used to operate the



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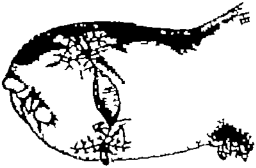

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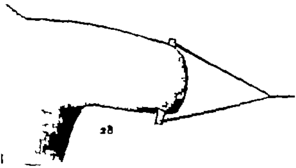

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FIGS. 26-28 —Cinematic amputation. Fig. 26 shows rectangular area of skin freed and sutured into tube. Tube is then drawn through muscle belly Fig. 27 shows denuded area covered rubber tube left in skin tunnel Fig. 28 shows method of attaching skin tunnel to appliance.

terminal part of the appliance (Figs 26-28) Cinematization as proposed by Vanghetti was tried and enlarged upon during the war It has a limited field of application

(1) Cinematization should be considered only in double amputation

(2) The vocational reëducation plan should be thoroughly worked out, in each case in advance of any cinematization efforts to improve stump function. After the trade, its tools and the operation of the tools by the available stump have been studied cinematization should be considered but only individually and selectively in each case. It is essential that the surgeon make an individual and personal study of the functional possibilities of the stump under consideration Physical

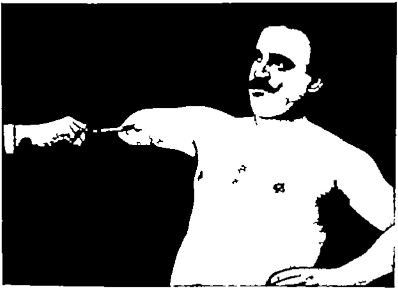


Fig. 29—Cinematization muscle power in the tunneled muscle motors must be developed before an ppliance is worn Furthermore, skin tolerance in the tunnel must also be developed. This may be done by passing a metal rod through the tunnel the rod being attached t a chain or strings which are connected t weight and pulley or force may be exerted manually as shown in this illustration. The chief value of this type of cinematization is that it facilitates the attachment of a work appliance instead of serving as an active motor to activat the end tools or the hand.

therapy really begins in earnest after the tunnels or club motors are healed surgically The aim of physical therapy of course is to develop tolerance in the tunnels or clubs to build up the cinematized muscle groups by means of massage and active muscle movements by means of direct attachment of the muscle motor to weights and pulleys (Fig 29)

Special Postoperative Treatment

Traction.—In all stumps in which there is even moderate tension traction straps should be applied in the operating room In undrained

cases it is best not to apply weights until the following day, unless tension is marked. If applied at once, traction seems to create dead space and favors the accumulation of clot. In addition to the advantages of traction previously mentioned, there seems to be no doubt that it adds to the comfort of the patient by preventing muscular spasm and that it is instrumental in preventing postoperative hemorrhage in the same way

Blood drainage should be removed in 48 hours. In case secondary hemorrhage occurs with ballooning of the flaps it is best to remove the sutures clean out the clot, and reapply traction Secondary infection is frequent in cases in which special attention has not been given to the elimination of dead spaces and in those in which secondary hemorrhage occurs

Use of Provisional Appliances

Amputations of Lower Extremity —In all stumps of the lower extremity with the exception of partial amputation of the foot and the Syme amputation a portion of the stump is called upon to function in a manner entirely new and for which it is poorly adapted, that is, weight-bearing Radical physiologic changes necessarily take place in the weight-bearing portion of the stump i e., pressure atrophy of the soft parts increased tolerance of the skin to lateral pressure from the encasing socket of the appliance development of balance and sense of position and tolerance to pressure on and adjacent to bony prominences The other important task of the stump leg is propulsion of the limb and its appliance. In spite of the fact that the artificial limb is not so heavy as the amputated part, more power is required to swing it on account of its comparative inertness. Increased difficulty in balancing undoubtedly adds to the demands made upon the muscular power of the proximal part of the stump leg Of vital importance is the preservation of normal muscular power or better the development of increased muscular power in the proximal part of the stump leg

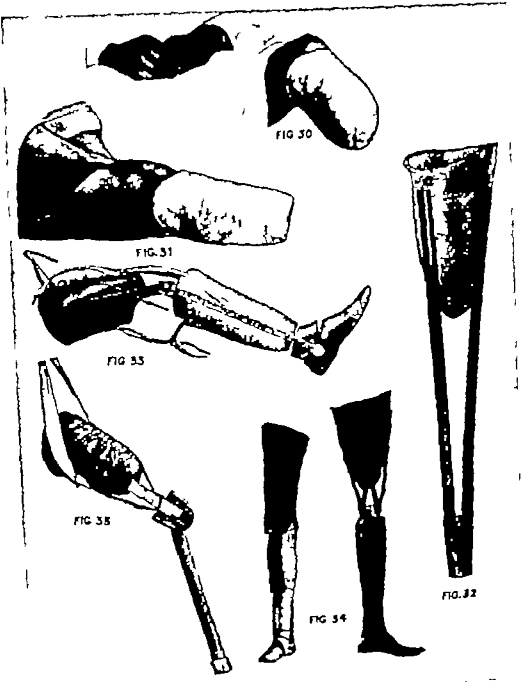
Inasmuch as certain definite physiologic changes must take place both in the stump and in the proximal part of the leg before a stump can be considered functionally fit for a permanent appliance, it is clearly the duty of the surgeon to use all methods at his disposal to hasten these changes and to obtain a good functional as well as a good surgical stump before a permanent appliance is used The development of provisional appliances which can be made cheaply and quickly under the supervision of the surgeon, has been instrumental in bringing about coördination of the surgical and prosthetic treatment of the stump This coördination existed in most amputation centers during and after the war but most surgeons have not appreciated the importance of supervising the early functional development of the stump and have reverted to the former practice of dismissing the patient to commercial limb makers after surgical healing is complete.

Principles of Fitting —Weight bearing in the case of below knee amputation is distributed as follows cone bearing (lateral surface bearing) bony-prominence bearing (head of tibia tuberosity of tibia, fibula below head) partial thigh surface bearing (thigh cuff) and in a certain percentage of cases end bearing In a finished appliance the stump is encased in a solid shell which is molded or carved to fit the stump in such a way that all the bearing points and surfaces are used to a variable degree. The physiologic changes in the stump will depend largely upon the predominating type or types of bearing chosen in a particular case

Cone and bony-prominence bearing with slight partial thigh bearing, are applicable to most leg stumps except the stump resulting from the Syme amputation. Pressure atrophy is rapid and marked consequently repeated remolding of the socket is imperative End bearing diminishes pressure atrophy of the stump In amputation of the thigh bony-prominence bearing (ischial tuberosity) cone bearing and in certain cases end bearing are utilized Bony prominence bearing predominates so that pressure atrophy of the stump is slower and less marked than in leg stumps

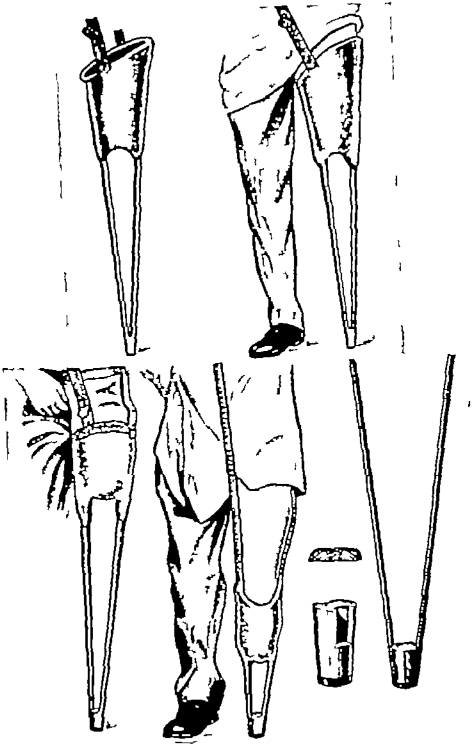
There seems to be no doubt that end bearing is possible in a fair percentage of stumps and that success in obtaining it is largely dependent upon faithfulness and persistence in carrying out the necessary preliminary measures to increase the tolerance of the end of the stump Experience seems to prove that a definite distinction must be made between total and partial end bearing and that in certain instances *total* end bearing may not be desirable, i e. in long below the-knee stumps. Cone and bony prominence bearing give nearly perfect function If end bearing is attempted in these stumps there is a certain lack of adhesion between the appliance and the stump and the gait is not so good as with cone bearing In thigh stumps of moderate length total end bearing is not preferable to ischial and cone bearing for the same reasons There is little doubt that *partial* end bearing is always an advantage The following stumps in addition to partial foot amputations are especially well adapted for end bearing (1) the Syme stump (2) short below knee stumps and (3) stumps resulting from a transcondylar thigh amputation. The section in each of these is through spongy bone which seems to give a more tolerant end bearing surface Each is clubbed more or less on the end thus favoring proximal methods of attachment of the appliance and avoiding the maladjustment of the appliance mentioned above.

Qualifications of Provisional Appliances —An ideal provisional appliance should possess in the main mechanical features similar to those in permanent appliances The socket should be of solid material and should be molded or carved in the same accurate manner as in a permanent one A provisional appliance which merely shrinks the soft tissues of the stump and does not develop the tolerance of the bearing

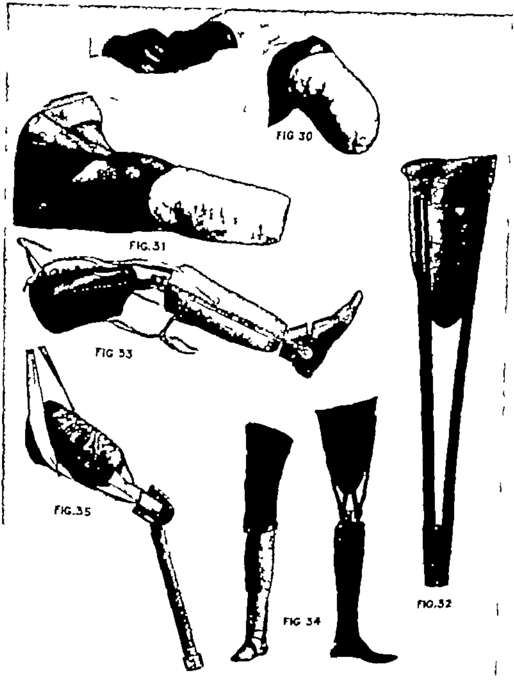


FIGS. 30-35.—Provisional type of limb with separate plaster socket mounted on a peg or stock frame with side bars. The plaster socket is made as follows. A stockinette is drawn over the stump. Plaster of paris bandages are applied immediately over the stockinette. No cotton is used. The molding should be accurate, and for below-knee stumps a small piece of felt should be placed over the head of the fibula and over the tuberosity of the tibia in order t make a slight indentation in the cast at these points. The frame for this type of socket may be a peg of either wood or metal which is riveted to the molded socket (Fig. 30) or the plaster socket may be set in a double-bar frame with an artificial foot as shown in Fig. 30 and thigh stumps as shown in Fig. 32.

FIG. 33.—Peg leg with a plaster socket riveted to steel bars, the peg being arranged so that it can be flexed when the patient sits.

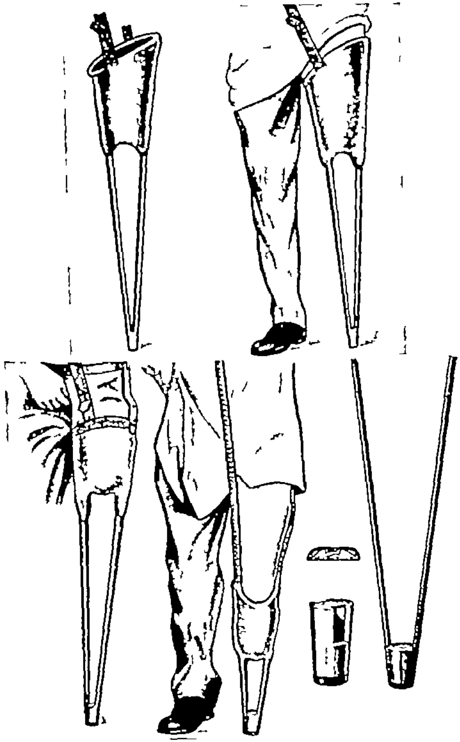


FIGS. 36, 37.—Simplest type of peg leg. The frame part may be made of wood or metal. The socket is made of plaster of paris, and the strap is of simple webbing. The strap goes across the opposite shoulder. This type of peg can be made in any hospital. In case difficulty is encountered in obtaining the wooden part of the frame a crutch may be used for this purpose. It will be noted that the frame is incorporated in the plaster socket and is not fixed by rivets.



FIGS. 30-35.—Provisional type of limb with separate plaster socket mounted on a peg or stock frame with side bars. The plaster socket is made as follows. A stockinette is drawn over the stump. Plaster of paris bandages are applied immediately over the stockinette. No cotton is used. The molding should be accurate and for below knee stumps a small piece of felt should be placed over the head of the fibula and over the tuberosity of the tibia in order to make a slight indentation in the cast at these points. The frame for this type of socket may be a peg of either wood or metal which is riveted to the molded socket (Fig. 30) or the plaster socket may be set in a double-bar frame with an artificial foot as shown in Fig. 30 and thigh stumps as shown in Fig. 31.

FIG. 33.—Peg leg with a plaster socket riveted to steel bars, the peg being arranged so that it can be flexed when the patient sits.



FIGS. 36, 37.—Simplest type of peg leg. The frame part may be made of wood or metal. The socket is made of plaster of paris, and the strap is of simple webbing. The strap goes across the opposite shoulder. This type of peg can be made in any hospital. In case difficulty is encountered in obtaining the wooden part of the frame, a crutch may be used for this purpose. It will be noted that the frame is incorporated in the plaster socket and is not fixed by rivets.

points and surfaces that will be called upon to function in a proper permanent appliance is not efficient The provisional socket must be one which can be remolded frequently and comparatively inexpensively In a certain percentage of cases, it is not only desirable but necessary to change the shape, as well as the position, of the socket. A complete change of socket rather than a reshaping is sometimes necessary This feature is important in all cases in which there is more or less malposition of the stump, the malposition improving with the use of the appliance

Types of Appliances—Various types of *temporary* appliances may be used In most of them the socket is made of plaster of paris and the framework of wood or metal. The various types are shown in accompanying illustrations (Figs 30-35)

The recent *amputé* is usually most concerned with removing his physical deficiency as soon as possible from an esthetic rather than from a functional standpoint. Pegs (Figs 36 and 37) and the cruder types of temporary appliances are strenuously objected to by many patients If the surgeon explains the physiologic and economic reason for the use of temporary appliances the assent and the coöperation of the patient will be obtained in most cases

An attempt was made in the United States Army to utilize a provisional leg which in all respects looks like a finished leg Of necessity, it was adjustable as to length foot position, and socket. The socket adjustment was accomplished by means of molded plaster of paris sockets which were made on the patient and then set into the stock frame of the provisional appliance. New plaster molds were made as the stump shrinkage progressed.

In addition to meeting the esthetic requirements more satisfactorily than the peg appliance, this type offered the advantage of quantity production and quicker fitting

In thigh amputation and in about 85 per cent of the cases where there was sufficient bone length to operate the ordinary thigh leg this latter type of provisional leg was entirely satisfactory (Figs 38-40) Most of the remaining 15 per cent fell into the class of excessively long stumps It was not possible to fit these on account of interference of the mechanism for the adjustment of length The greater part of the weight rests on the tuberosity of the ischium, and accurate cone bearing is relatively unimportant consequently the cone fitting does not need to be very exact. In leg amputations the task of fitting this type of leg was much more difficult (Fig 41) Bony prominences are more numerous and less tolerant to weight bearing Consequently the bony-prominence fitting must be more accurate and a great amount of weight bearing must be allotted to the cone fitting For this reason the latter must be more precise.

In order to meet the requirements of the more difficult cases which could not be fitted with the original model of the stock appliance, a more versatile type was developed and the stock parts (framework)

manufactured in quantity in a variety of sizes, the only essential difference from the original model being that a carefully-molded plaster socket was made and riveted to the side bars

The plan generally adopted in all amputation centers is to fit the stump with a temporary appliance as soon as healing is complete but not to hasten the prosthetic treatment at the expense of a good surgical result (Fig 42) The appliance is worn at first to the limit of tolerance special care being taken not to damage the soft parts The part of the appliance which encases the terminal part of the stump commonly called the socket is changed and refitted as pressure atrophy pro-

FIGS. 38-40.—Stock provisional appliances used in army hospitals during the War The main body of the limb is made of fiber with connecting parts of metal. A variety of sizes and lengths was supplied in stock. Adjustments for length were made both below and above knee merely by sawing off as much fiber as was necessary The socket was fitted by means of an adjustable leather cuff. This was later abandoned and molded plaster of paris sockets were made over the stumps and then set into the fiber frame of the limb

FIG 39.—Patient wearing below-knee limb of this type. The plaster socket is resting between the artificial limb and the patient's left leg. It appears dark because it has been shellacked to protect it from perspiration

FIG. 40.—Below-knee stump with plaster socket.

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culature of the proximal part of the leg well developed The stock provisional appliance is sufficiently durable to last from eight months to one year Three to six months preliminary prosthetic treatment is usually sufficient to prepare stumps for the permanent appliance.

Partial amputations of the foot Syme stumps end bearing thigh amputations and disarticulations of the hip do not require provisional appliances as a rule In these stumps the fitting is difficult and there is so little change in the stump compared with changes in stumps in which cone and bony prominence bearing predominate, that there is no reason to delay the permanent fitting

Amputations of Upper Extremity.—The use of provisional appliances in amputations of the upper extremity does not seem to be so

FIG. 41.—First temporary appliances f short thigh stumps in double amputation It is advantageous in double amputations of the thigh to hav the temporary appliance very much shorter than the normal length, as it is very difficult f these patients to regain the sense f balance and equilibrium. As skill in walking with the short pegs is developed, the length may be increased. (Courtesy Letterman General Hospital, San Francisco Calif)

necessary from the standpoint of fitting as in amputations of the lower extremity The physiologic changes in the stump caused by the use of the appliance are not marked enough to require frequent refittings and an exact fitting is not so necessary as in lower-extremity stumps The chief advantages in provisional fitting are that (1) immediate fittings are possible which would not be the case in time of war if permanent appliances were supplied by the artificial limb industry (2) an opportunity is given to coördinate the surgical prosthetic, and physical therapy treatment and to carry out a reëducational program

gresses Three changes are usually required. Deformities and surgical defects of the stump i.e , bony spurs, latent infection, tender nerves, etc , will be readily discovered and should be treated during this preliminary prosthetic treatment. Stumps should not be fitted with a permanent appliance until they are surgically sound, pressure atrophy of the weight bearing portion well advanced, and the propulsive mus-

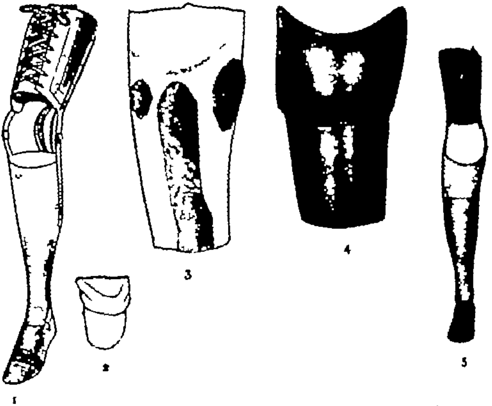

FIG. 41.—The United States Army temporary below knee prosthesis.

1 The temporary below-knee fiber set up as supplied by the Minneapolis Artificial Limb Co. The side steels are removed by cutting the copper rivets which secure them to the vulcanized fiber shin piece. The shin piece can be shortened to desired height by sawing off its top made larger or smaller by removing the copper rivets posteriorly which secure the overlap seam of the prosthesis. There is ankle and toe motion, the foot is of wood, uncovered and not painted.

2 A plaster socket is molded to fit the stump and secured in the upper end of the fiber shin piece where it is made fast. This type of socket is short-lived but easily changed as shrinkage occurs.

3. A plaster model of the stump with areas built up with felt where pressure cannot be borne The line around the top indicates the future top of the bucket. Around this corrected model of the stump three layers of thin harness leather are molded. They are glued together and sewed posteriorly with wax-end. The last layer of leather extends only part way down the bucket, acting as a shoulder which supports it in the fiber shin piece.

4. The finished molded leather bucket, ready to be secured to the fiber shin piece. It is of rigid construction.

5. The temporary below knee prosthesis complete, aligned and ready for use. The bucket is securely fixed to the upper end of the fiber shin piece, the side steels have been adjusted and riveted in position. The upper end f the shin piece the leather bucket and side steels are covered with calfskin, which is fixed in position with glue or cement. (Orthopedic Shop, Walter Reed Hospital.)

attachment plate in which a hand tools or any type of hook or other useful device could be used interchangeably was adopted. The metal parts were manufactured in quantity and issued to amputation centers Sockets were made of leather and the work of fitting was done in appliance shops. Workmanship and exactness of fitting were probably not equal to those obtainable in the open market but the arm served the purpose as a provisional appliance as well as could have been expected from any single type of appliance obtainable (Fig 43)

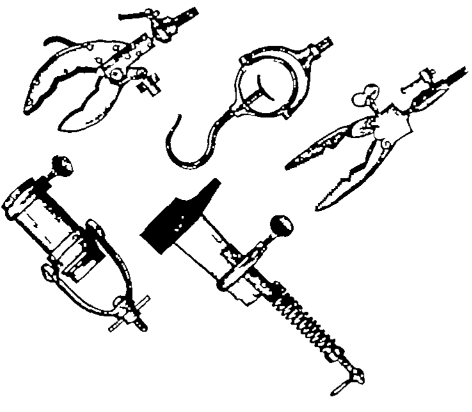

FIG. 44—In the provisional arm with universal end plate, any number of attachments may be devised and inserted. This illustration shows a collection of tools fo agriculture namely the claw pincers, the sleeve for handled tools, the open hook, and the hammer attachment.

Occupational Therapy and Reëducation.—LOWER EXTREMITY — In lower extremity cases the actual use of the appliance in walking is the only reasonable means of occupational therapy so that if regular tasks are to be assigned they should be those which require walking under varying conditions i e steps irregular terrain etc In double amputations considerable assistance and instruction are necessary at the start. At first crutches and quadruped progression must be resorted to Later a double-rail walking platform with grades and steps

which is often more helpful than the appliance per se, (3) surgical defects of stumps become apparent while the patient is still under control of the surgeon and can be corrected at once, (4) the patient has an opportunity to learn something about appliances and is thus able to make a more intelligent choice of a permanent appliance.

The first provisional appliances used in the army were of a simple design and were rather crudely made. The socket was of plaster of paris In the end of the socket was incorporated a metal clamp to hold various implements Later an inexpensive arm, with a universal end-

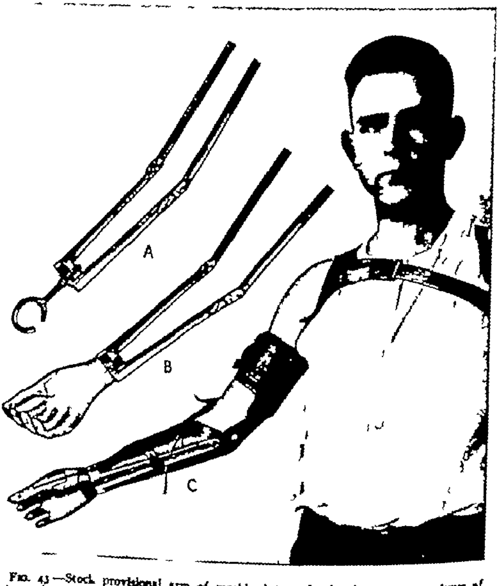

FIG. 43.—Stock provisional arm of combined type for hand or numerous types of end attachments (A) Unfinished metal frame with universal end joint with simple split ring inserted. Any type of tool may be devised and inserted in this universal end plate. When the arm is t be used purely for esthetic purposes, the hand is inserted in the end plate as shown in (B) and (C)

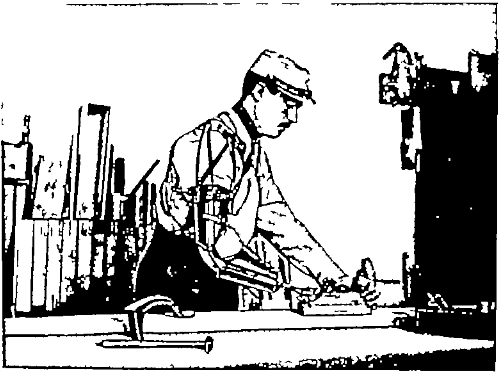

FIG. 47—An adaptation f a plane with the appliance.

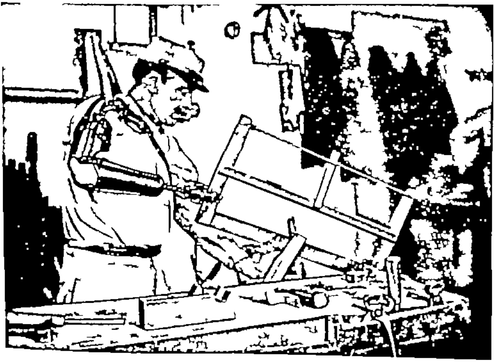

FIG. 48.—Adaptatio fo saw

FIG. 45.—During the development of the musculature of the stump, occupational therapy may be considerably facilitated by making adaptations of tools and work ppliances to fit the stump rather than by depending entirely on the apparatus which is fitted to the stump. An example of this type f occupational therapy is shown in this illustration Adaptations of sport implements (i e golf stick, ping-pong racket, billiard cue) were successfully made in army shops during the Wa These are very valuable during the development of the musculature of the stump and re a helpful factor in improving the mental state f the patient.

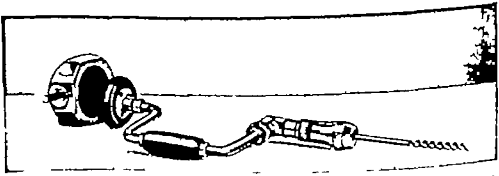

FIG. 46—An adaptation t enable a person with an amputated limb to use an auger

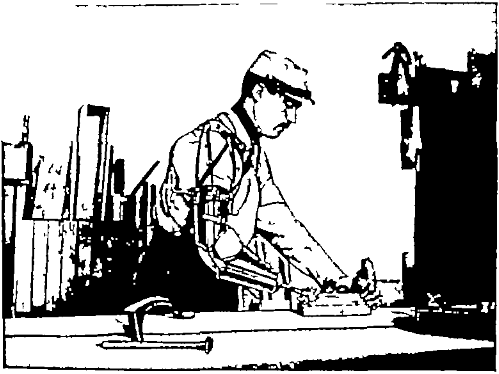

Fig. 47.—An daptation of a plane with the appliance.

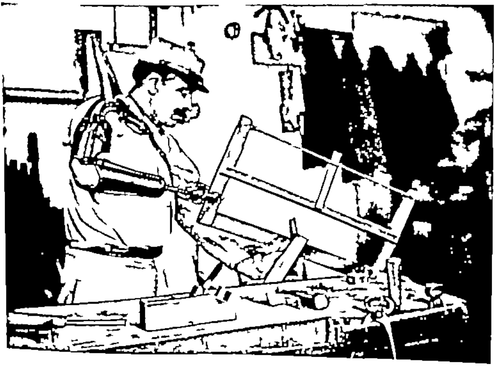

Fig. 48.—Adaptation for saw

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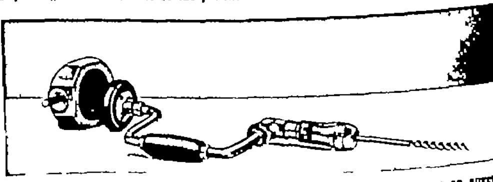


FIG. 46.—An adaptation to enable a person with an amputated limb to use an auger.

may be attempted without crutches. Finally, independent walking preferably under the instruction of a person with an amputation is attained.

UPPER EXTREMITY —Occupational therapy is made possible first, by the early fitting of temporary appliances (Fig 44) of such type that many varieties of tools may be inserted in a universal end attachment and secondly by the adding of attachments which will permit the stump arm to be used as an auxiliary without an appliance (Figs 45 50) thereby bringing it into functional if not vocational use, for therapeutic purposes

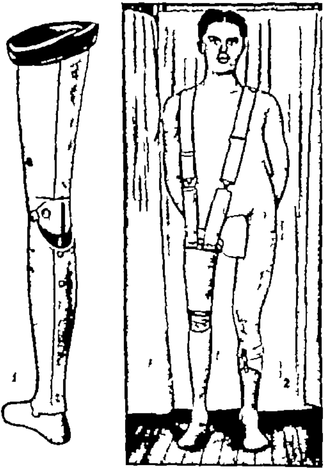


FIG. 51 —The United States Army temporary thigh prosthesis, ischial bearing.

1. The temporary fiber prosthesis without suspenders as supplied by the Minneapolis Artificial Limb Co. This prosthesis is adjustable and readjustable as to length and alignment, as to size of thick bucket, and as to the distribution f weight on nonweight bearing and weight-bearing points. This temporary prosthesis has the same knee, ankle and toe motions as the permanent type of prosthesis. The bucket is of rigid type but adjustable.

The temporary fiber ischial bearing prosthesis fitted and properly aligned, with suspenders ttached (Courtesy Orthopedic Shop Walter Reed Hospital.)

FIG. 49.—Adaptation for hammer and file.

FIG. 50.—Adaptation for handled tools.

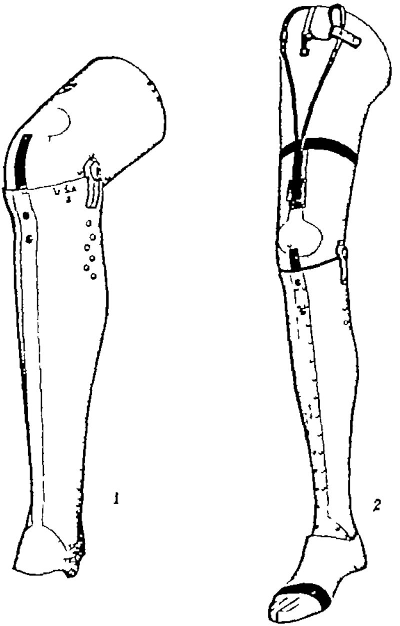


Fig. 53 —The duralumin prosthesis.

Duralumin "set up" consisting of shin piece, knee joint, and knee block made of duralumin. The prosthesis is completed for the ischial bearing type by adding wooden thigh bucket and wooden foot as shown in 2 The set-up weighs two pounds and two ounces. The completed prosthesis weighs about four pounds

The duralumin ischial-bearing prosthesis with willow bucket. Shoulder straps are shown entering the anterior surface of knee block for knee control. The duralumin leg has become very popular on account of its light weight. (Courtesy J E. Hanger Inc.)

There is no doubt that there are insurmountable problems connected with the replacement of hand function by the mere substitution of a prosthesis. Real progress in improving the function in arm amputations depends upon first, reëducation of the remaining hand in single amputations, and, secondly, reconstructive surgery in double amputations together with individual development of special appliances for particular trades

In teaching patients who have undergone recent amputation how to take care of the acts of personal necessity—dressing etc.—arrangements should be made to secure the services of an experienced person who has undergone an amputation, as it is impossible for an unamputated person really to aid as an instructor This plan was followed in

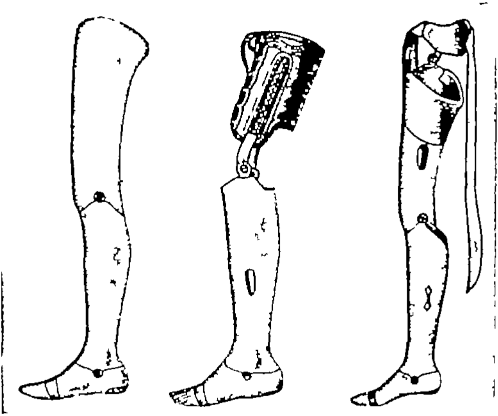
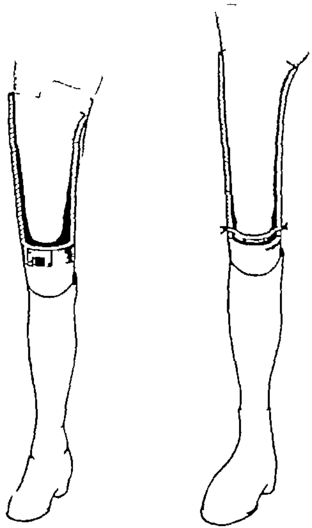


FIG. 52.—Willow legs f ischial bearing thigh and below-knee amputations without suspenders. The feet are made f willow and wood allowing toe motion and articulate at the ankle joint with the shin piece which is made of willow The knee joint of the thigh prosthesis is f the cordless type The buckets f both the below-knee and thigh prostheses are machine made The legs are covered throughout including the feet with rawhide which is painted with waterproof flesh-colored cement.

The willow socket is at times modified and a "leather back" socket made, which can be used f r stumps with length f more than six inches. The willow is cut away and a rigid leather back substituted. The leather back socket is more comfortable to sit in and is easier on clothing than the solid wooden socket as the leather is softer and tends to flatten out when the amputé sits down, as does the normal thigh. (Courtesy J E. Hanger Inc.)

Upper Extremity —Finished appliances for the upper extremity as offered by the commercial market should be considered only from the standpoint of general utility as such arms are seldom of much value vocationally They are useful in carrying as the fingers can usually be locked in flexion or set permanently in flexion with a movable thumb



FIGS. 55, 56—Ischial bearing is the predominant type of bearing in all amputations f the thigh (Fig. 53) except transcondylar which is shown in Fig 8 In the latter not that hammock is suspended in order to permit end bearing In some finished appliances, the terminal part f the socket is shaped and the hammock is not used.

and they are useful as an auxiliary in single amputations Practically all arms offered have similar features—namely a rotating wrist and a movable thumb which apposes to fixed fingers by spring action the fingers being in slight flexion The thumb is usually operated by a cord extending to the opposite shoulder

the army and should be used by all surgeons who are doing amputations

Permanent Appliances

Lower Extremity —Partial Foot Amputations —The appliance for a partial foot amputation requires a fill of cork and metal reinforcement in the toe of the shoe to keep it from turning up Chopart amputation requires, in addition, anchorage in the form of a molded leather lacing, with side steels extending up to the knee. Syme amputation requires an ankle joint and side bars, either lateral or anteroposterior

Below Knee Amputations —The socket is made of willow and is shaped by routing with a drawknife. It is anchored to the foot by steel

Fig. 54—Types of prosthesis made for partial foot, the Chopart, and the Syme stumps (Courtesy E. H. Erickson Co)

bars which are set into the wood. The entire limb except the joints at the ankle and the knee is covered with rawhide. Lateral steels extend above the knee To these are attached a leather thigh cuff which is laced to the thigh (Figs. 51 54)

Thigh Amputations —The main body of the limb is made usually of willow or aluminum (Fig 8) In either case the socket is of willow The knee action is either automatic (spring control) or is controlled by a strap which goes over the shoulder The weight-bearing is on the tuberosity of the ischium in most thigh stumps except the transcondylar (Figs 55 and 56) In the latter total end bearing is possible

Redundancy.—Many stumps become redundant after prolonged use of an appliance so that the skin hangs in folds Fissures form between the folds and become the seat of various types of dermatitis If redundancy is marked and fissures and dermatitis are continually interfering with the functional use of the limb it is best to perform a plastic operation to correct the redundancy rather than to temporize with local treatment.

Ulceration.—When patients pass middle life, ulceration near the end of the stump is very common Frequently the ulceration is due to

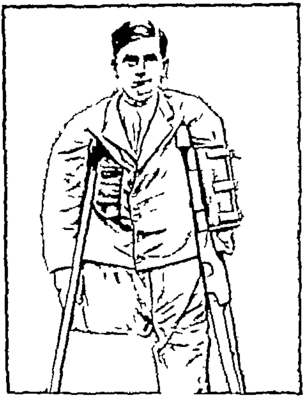


Fig 57.—Method of using crutches in the case of an arm stump

the original pathology for which the amputation was done such as Buerger's disease diabetic gangrene senile endarteritis etc. In many of these cases the more recent procedures recommended for the improvement of low vascularity in the extremities should be tried before reamputation is considered—namely perivascular sympathectomy ganglionectomy intravenous saline injection

Nerve Bulbs.—Tender nerve bulbs of course should be removed if they interfere with the use of the appliance

In amputations above the elbow, a joint is supplied at the elbow and flexion is accomplished by a forward swing of the stump In upper-arm stumps, of course attachment to the shoulder is necessary The problem of vocational appliances in amputations of the upper extremity should be worked out in each individual case, and the appliance should be so designed as to be an auxiliary to the remaining arm in the daily work of the individual

Care of the Stump

The minor ailments of the stump and difficulties with the socket of the appliance seldom come to the attention of the surgeon as he usually does not see his patient after an appliance has been fitted. The limb fitter being eager to please and hold his client, who, of course, is a potential customer for the rest of his life, attempts to give advice on all questions regarding the stump Due credit for this service should be given to fitters whose advice is usually helpful, as the majority of them are themselves, wearers of appliances but it frequently happens that definitely indicated treatment of the stump is delayed and disability prolonged by withholding medical counsel. Surgeons should insist on following their amputation cases until the permanent appliance has been worn for at least a year, as many stump troubles will appear during that time.

Variation in Size of the Stump.—Usually at the time a permanent appliance is fitted the stump has not thoroughly "shrunk." In order to avoid frequent changes of the socket adjustment for the shrinkage is accomplished by adding stump socks Stump socks are supplied in wool and silk wool and can be obtained at any appliance house. All stumps should be protected with well-fitting stump socks when the appliance is being worn Frequently patients are at a loss as to why the artificial limb will fit one month and not the next. As a rule, the explanation lies in the variation of the size of the stump which increases or decreases as the patient gains or loses weight. Usually, in the morning some difficulty is encountered in properly fitting the stump into the socket of the appliance due to the fact that the stump has enlarged slightly during the night.

Chafing.—Early in the functional use of the stump, considerable difficulty is encountered because of chafing of the skin at the points where pressure is exerted. Later callosities may develop at the same points In below-knee stumps these points are under the head of the fibula on the tuberosity of the tibia and along the inner surface of the head of the tibia. Treatment of this condition consists in proper local care of the chafed area and remolding of the interior of the socket at intervals.

Redundancy.—Many stumps become redundant after prolonged use of an appliance, so that the skin hangs in folds Fissures form between the folds and become the seat of various types of dermatitis. If redundancy is marked and fissures and dermatitis are continually interfering with the functional use of the limb it is best to perform a plastic operation to correct the redundancy rather than to temporize with local treatment.

Ulceration.—When patients pass middle life ulceration near the end of the stump is very common Frequently the ulceration is due to

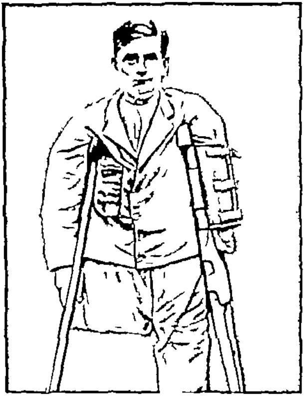


Fig. 57.—Method of using crutches in the case of an arm stump.

the original pathology for which the amputation was done such as Buerger's disease diabetic gangrene senile endarteritis etc. In many of these cases the more recent procedures recommended for the improvement of low vascularity in the extremities should be tried before reamputation is considered—namely perivascular sympathectomy ganglionectomy intravenous saline injection

Nerve Bulbs.—Tender nerve bulbs of course should be removed if they interfere with the use of the appliance

Sensations in Amputated Part.—Shortly after amputation, a very high percentage of patients will complain of pain numbness, par esthesia, etc. in certain parts of the amputated limb As a rule, it is not necessary to take these subjective symptoms seriously, as it is not long before they are forgotten by the patient.

Use of Crutches

Unless the patient is supplied with a reserve artificial limb it is inevitable that a fair portion of his time must be spent using crutches while repairs are being made. All persons who have undergone amputations use crutches when the appliance is not worn as in bathing etc. It is well for the surgeon to give every patient who uses crutches simple instruction in their use The weight in crutch progression should be borne chiefly on the hands and the axillary rest should take only part of the body weight In the forward thrust of walking, most of the weight should come on the hands When the patient stands he will usually allow most of the weight to come on the axilla thereby giving the hands a rest. If the crutches are too long bearing will be predominately axillary and may lead to crutch paralysis, or slow atrophy of the arm. Occasionally one is called upon to take care of a patient who has had multiple amputation. When both an upper and a lower extremity are amputated the question of walking with crutches necessitates some adaptation to the crutch, in order to enable the patient to walk with crutches (Fig 57)

Summary of Physical Therapy

In every case a person who has undergone amputation is a potential physical therapy patient. In the majority of cases physical therapy should start within a few days following the amputation In infected cases or guillotine amputations a portion of the physical therapy measures must be delayed until healing of the stump is secured but even then a certain amount of physical therapy is indicated The chief physical therapy measures indicated are massage motion, hardening of the stump splinting and the supervision of the wearing of the prosthesis

Massage.—Light stroking massage should be started on the stump just above the protective dressing and continued up the limb growing more forceful and stimulating as the upper limits of the extremity are reached As soon as the incision is healed light stroking and kneading massage should be started over the end of the stump The purpose is to relieve sensitiveness and accustom the patient to the touching and handling of the stump (a most important psychologic effect) to prevent adhesions and keep the end of the stump pliable and finally to prepare the stump for end or partial end bearing This massage

should be continued even after discharge from the hospital in cases of adherent scar contractures and impaired function in adjacent joints (Fig 58)

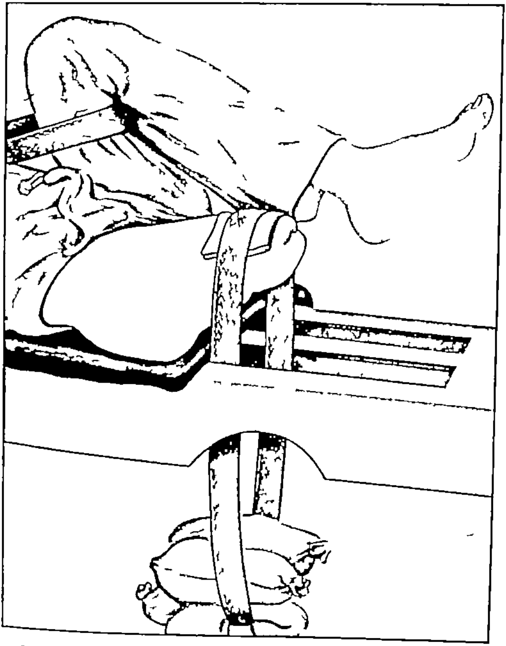


FIG. 58.—Special massage table for treatment of flexion deformity in thigh stumps. The pelvis is fixed by a webbing strap which holds the normal thigh in flexion. The strap is secured around the patient's shoulders. Traction is made downward by sand bags which are placed in webbing strap which encircles the end f the flexed stump while the tense soft parts about the groin re massaged. (Army Med. Museum)

Motion.—Passive and active motion of the stump and the adjacent joint should start within a few days after the amputation. At first the surgeon must gently move the joint, but within a few days the patient must be taught and stimulated to move the extremity and to flex and extend the adjacent joints several times a day. The trained technician should teach and supervise these movements following the massage.

Hardening of Stump.—Accustoming the stump to end bearing and hardening of the stump can likewise start within a few days. As soon as active motion has developed the patient should be taught lightly to tap the end of the stump covered by its dressing on a pillow. Later when the wound is healed, this tapping on a pillow is continued with

FIG 59.—A repaired guillotine stump.

A circular guillotine operation was perf rmed early in 1935 for the control of a chronic active osteitis of the middle third of the femur. This infection had persisted since his riginal gunshot injury sustained in 19 8. Recurrent hemorrhage had followed an operati e procedure on the femu and the foot showed evidence of circulatory disturbances. The patient was septic.

The amputation was performed through the middle of the osteomyelitic area. Dakinization and skin traction were begun at once. There were four large scars extending up the thigh, adherent t the femu the result of former drainage incisions.

All scar tissue was removed from the stump at the time of plastic closure. The bone end was rounded off and skin closure accomplished without bone shortening. The stump end is painless, even with direct weight bearing. The skin is not adherent to the bone end. He w fitted with an ischial-bearing prosthesis.

the stump end exposed The hardness of the surface being tapped is gradually increased until the patient, within two or three weeks is striking his stump rather forcibly against the bottom of a chair or the surface of a table (Fig 59)

Splinting —Splinting to prevent joint contractures and faulty positions of the stump and traction either for the same purposes or to secure better skin covering of the stump are likewise physical therapy measures which must not be neglected in indicated cases.

Wearing of Prostheses.—Finally the surgeon who is rehabilitation-conscious must recognize the importance of supervising the wearing of temporary and permanent prostheses until the patient has regained the greatest possible functional restoration in the handicapped extremity

CHAPTER FOURTEEN

PHYSICAL THERAPY IN RELATION TO THE SURGICAL TREATMENT OF ARTHRITIS

BEVERIDGE H MOORE, M.D

INTRODUCTION

Definition.—In discussing this subject it is well to define clearly the ground to be covered It is not the intention to discuss the physical therapy of arthritis that is taken care of in another chapter This one is concerned only with the surgical treatment of arthritis in its relation to physical therapeutic measures There is a dearth of literature on this subject. Most of the available articles describe minutely the details of the operative procedure and then blandly remark that physical therapy is a valuable adjunct in the after-care leaving the reader to form his own conclusions as to how or why Another point that should be cleared up preliminary to a discussion of the subject is a definition of arthritis The classification of arthritis is at present in a deplorably muddled state There is confusion as to the nomenclature of the various types and to make matters worse some authors are including pyogenic tuberculous and gonorrheal joints in the class of arthritis These conditions undoubtedly are inflammations of the joints but to include them under arthritis is to add an unwarranted burden to an already overburdened classification What the field of arthritis needs is narrowing rather than broadening. For the purpose of this chapter then arthritis will be considered as an affection of the joints in which there is no demonstrable infection present in them though they are the site of pathologic changes That is it is the chronic nonsuppurative arthritis which is being considered in this chapter This will include the classes usually called hypertrophic osteo-arthritis and atrophic or rheumatoid arthritis

INDICATIONS FOR SURGERY

Another point which I wish to bring out clearly is that I am by no means advocating operative surgery on all cases of arthritis even in the limited field which I have defined. I wish to make this as emphatic as possible There are cases of chronic arthritis which can be benefited by operative surgery but they represent a relatively small proportion of the total number As a general rule operative surgery should not be considered while the condition is acute Since arthritis during this

stage is a general disease, although its chief local manifestations are in the joints, all the measures of general medicine, including diet, and physical therapy should be given a thorough trial before operative measures are considered. As a matter of fact, the question boils down to this Surgery is more often useful in the treatment of the sequelae of arthritis than in the treatment of arthritis itself

I would give, then, as the two principal indications for surgery in arthritis first, the relief of pain, and second, the correction of deformities resulting from arthritis which are causing disability These two indications, of course will overlap to a certain extent, and in any individual case both may be present in varying proportions. It is quite logical to believe that a joint deformed by arthritis will be more subject to pain simply because it is at a mechanical disadvantage in meeting the strains for which the normal joint is perfectly adapted.

With regard to the first indication, the relief of pain, there is nothing that calls for more delicate judgment on the part of the surgeon. Much depends in this case on the personal equation of the patient. There is no standard by which pain can be measured by another person than the one enduring it. What one person may regard as excruciating agony will be regarded as discomfort by another, though so far as the physician can determine, the two may be pathologically exactly alike

With regard to the second indication for surgery, the relief of the deformity with resulting disability, there is not quite the same indefiniteness. It is obvious that a deformed joint, for example, a knee flexed 45 is not as useful for weight-bearing as one that is in normal position Hence if we can place this joint in a position which will be mechanically better we have benefited it.

Relief of Pain

The operation most commonly used for the relief of pain in arthritis is some form of ankylosing operation by which the bones forming the offending joint are fused together It is based on the theory that no joint at all is better than a painful one—a point of view with which many patients who are suffering are quite willing to agree The regions in which fusion operations are of particular value are first, the sacro-iliac second the spine third the hips, fourth the shoulder

Arthrodesis of Sacro-Iliac Joints

The sacro-iliac joints are small but exceedingly troublesome when affected by arthritis. In a recent questionnaire by the Clinical Orthopedic Society with regard to the question of the cause for low back pain it was the almost unanimous opinion that arthritis of the sacro-iliac joint was the most common cause The frequency with which arthritic changes are noted in x rays of the sacro-iliac region bears

this out. It has been frequently noted that in such cases the pain has disappeared when the sacro-iliac joints have become completely fused by the pathologic process This furnishes the rationale for fusing them by operative means—that is it is a matter of assisting nature to do in a comparatively short time what she will eventually do herself thus shortening the patient s period of disability Numerous methods of fusing these joints have been devised by Smith-Peterson Campbell, Gaenslen Chandler Verall and others

Operation.—The operations are all of two types one in which the joint itself is cleaned out and fused and the other in which the joint itself is not touched but is completely immobilized by building a bridge of bone across the joint, i.e , an extra articular fusion

In the Smith Peterson operation which is one of the first type a square of bone is cut from the ilium directly over the sacro-iliac joint which is curetted out through the opening and the square of bone is replaced. Gaenslen reaches the joint by cutting through a portion of the posterior wing of the ilium, turning it back and curetting out the joint. Campbell s and Chandler s operations are very similar and are of the second type. Both do an extra articular fusion of the sacrum and ilium by stripping away the periosteum from a portion of the sacrum and ilium and then building a bridge of the bone chips removed from the ilium across the sacro-iliac joint, causing an extra articular fusion with resulting immobilization of the joint Verall places a graft from the tibia across the posterior portion of the sacrum and ilium. All these methods have the same object in view that is the prevention of motion in the sacro-iliac joint In one type this is obtained by destruction of the joint with a resulting fusion in the other type, by a fusion between the sacrum and the ilium

After Treatment.—The primary object of the operation must be kept firmly in mind—that is a bony union between two surfaces In order to obtain this the involved bones must be held immobile until union has formed It must also be remembered that it takes somewhat longer to obtain a fusion where a joint has been removed than where a fracture has occurred in a bone How this immobilization is to be accomplished is largely a matter of taste with the surgeon. In the first stage it will be obtained by rest in bed with the patient lying on the abdomen, at least for the first two weeks This stage of rest in bed will last from four to six weeks Following this sufficient immobilization can be obtained by a plaster cast The sacro-iliac joint is not an easy one to immobilize and so the plaster must be applied skillfully to be effective This stage will last from six to eight weeks when the fusion should be strong enough to allow the patient to be about with a well fitting belt for support.

Physical Therapy —Again the primary object of the operation must be borne in mind. Any manipulation which would tend to move

the affected joint is taboo especially during the early stages However, local heat is often agreeable and by causing local hyperemia it may hasten the process of consolidation. Massage of the muscles of the thighs, legs, back, and arms is of benefit, in that it tends to keep these muscles in good condition and thereby shortens the period of convalescence after the fusion is firm enough to permit weight-bearing while still supported

ARTHRODESIS OF SPINE

The theory underlying the use of spinal fusion for arthritis is, of course, the same as with the sacro-iliac joint that is no joint is better than a painful one The operation is especially applicable to osteo-arthritis of the spine, in which the process is fairly well limited to one region The cases in which the radiograph shows large crescentic lipping extending from the border of one vertebral body to the adjacent one are especially favorable. As to the technic of the operation, it is not necessary to go into the details since it has been described so many times in the literature of more recent years It is sufficient to say there are two main types of operations for spinal fusion, the Hibbs and the Albee In the Hibbs operation no extraneous bone is used, while in the Albee type operation a bone graft removed from another part of the body is applied to the spine to cause fusion. Each operation has advantages and the choice must be made by each individual surgeon. Either type will give satisfactory results in the hands of a competent operator

After Treatment.—After treatment does not differ materially from that of sacro-iliac fusion, consisting of rest in bed support by plaster cast and then braces The spine is somewhat easier to immobilize by plaster than is the sacro-iliac joint, and it seems that weight-bearing when the spine is well supported by a plaster cast which fits well tends to give earlier and more solid fusion.

ARTHRODESIS OF HIP JOINT

Fusion of the hip joint has not a wide range of application. It is limited to those cases in which only one hip is affected and affected badly The usual type of this case is that of osteo-arthritis in which the head is badly mushroomed and deformed by the pathologic process There are two methods of obtaining a fusion of the hip joint, the intracapsular and the extracapsular In the intracapsular method the hip joint is opened and the head exposed and denuded of cartilage The cartilage of the acetabulum is also removed thus bringing raw bone in contact with raw bone. The operation is not an easy one in fact it is a very difficult one Furthermore, while the placing of raw bone against raw bone should theoretically produce union it does not always do so and the hip joint is notoriously a

hard one to fuse However Magnuson states that he has had several cases in which although fusion was not obtained by this method there was great relief from the pain

After Treatment.—In obtaining fusion of the hip the after treatment is governed by the same principles as those which apply to the spine Immobilization should last for a period of three to four months with weight-bearing while immobilized after four to six weeks In obtaining immobilization of the hip a plaster cast is the most effective agent The choice of position for ankylosing a hip joint is very important The position usually chosen is full extension of about 15 and neither internal nor external rotation. This position is undoubtedly the best for walking or standing but is not so convenient for sitting In order to sit comfortably with a stiff hip in the fully extended position, the patient must develop compensatory motion of the lumbar spine Therefore before recommending a fusion for an arthritic hip it is important to assure one s self that there is no arthritis in the lumbar spine No form of traction should be used after an operation to secure fusion of the hip This is obvious since in order to secure fusion the bony surfaces must be forced together whereas traction draws them apart. It should be borne in mind that after a successful fusion operation the muscles which ordinarily act on the joint tend to atrophy rapidly since the fusion has robbed them of their function This is the converse of the operation in infantile paralysis where the fusion is done to stabilize a joint which cannot function properly on account of a loss of power in its muscles Massage will tend to delay this muscular atrophy but will not prevent it, since it is a result of a loss of function However in the three joints discussed the sacro-iliac, spine and hips the atrophy of the muscles is not of the consequence that it is in other regions of the body

ARTHRODESIS OF SUBASTRAGALAR, ASTRAGALOSCAPHOID AND CALCANEOCUBOID JOINT

Another joint in which arthrodesis may be considered as a treatment for arthritis is the subastragalar astragaloscaphoid and calcaneocuboid joints considered together The special indication for fusion in this region is that type of arthritis not infrequently seen following a fracture of the os calcis The arthritis of the subastragalar joint causes persistent pain and disability Subastragalar arthrodesis similar to that for stabilization of a paralytic foot gives excellent results in these cases The technic consists in clearing out the tissues from the sinus tarsi to give access to the astragaloscaphoid calcaneoscaphoid and calcaneocuboid joints The cartilage and a portion of the bone are then removed from each of these joints It is possible by a little care to remodel the bones so that the weight-bearing can be much improved

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popliteal space from the side This gives rather free access to the posterior portion of the capsule without great danger to the popliteal vessels and nerves The capsule is then either divided or stripped from its attachment to the posterior surface of the femur

After Treatment.—In the after-care of these cases it is very important to remember that if the contracture is of long standing not only are the tendons and capsule contracted but also to some extent at least the large nerves and the popliteal vessels are tight. To attempt to stretch them violently may result in disaster—either shutting off the circulation of the leg or tearing the popliteal nerve trunks Therefore it is better to use some apparatus for gradual stretching The simplest is a circular plaster cast applied from the groin to the ankle with the knee in flexion Before it hardens completely a circular cut is made behind the knee leaving about two inches of plaster intact over the patella to act as a hinge Then in two or three days this is opened by extending the knee and placing thin strips of wood in the cut to hold it open. These are added to each day and the extension is thereby increased until the full amount is obtained Other more elaborate devices have been invented but this method is the simplest and is effective After the full amount of extension has been obtained the knee should be retained in that position for about six weeks longer in order to prevent contractures from recurring

Physical Therapy —The next step is beginning to secure motion by passive movement, massage and heat These are great aids at this stage The passive movements must be gently and slowly done going to the point where the movement begins to be checked then very gently a little beyond that and holding the stretch obtained for a few seconds. These movements occupy but a very small portion of the day and it is to be remembered that contractions may recur during the rest of the day Some form of removable splint to retain the position should be worn continuously The stretching and massage should be kept up for several weeks until the motion present is smooth and entirely painless though probably not the normal range of the joint. Then function should be very gently begun First should be supported weight-bearing then walking with the aid of crutches The natural function of the joint is the greatest aid to improvement from this point This is a very tedious process and by no means all patients will show improvement commensurate with the time and difficulty involved but some will be benefited enough to be freed from a wheel chair existence which is no bed of roses

REMOVAL OF EXOSTOSES

Another operative measure for the relief of deformity that may be necessary is removal of exostoses resulting from arthritis This of

After Treatment.—Following the operation the bones are retained in close apposition by plaster and early weight bearing—that is as soon as it can comfortably be done—is encouraged while the foot is supported by the cast. From 8 to 12 weeks usually suffice to give a firm ankylosis Following this, massage with passive and active motions should quickly restore function to the ankle joint. The manipulation around the ankle joint should be limited to dorsiflexion and plantar flexion The reason is that these motions are a function of the tibio-astragalar joint whereas lateral motion takes place chiefly in the joints we are attempting to ankylose. Hence, no attempt should be made to secure lateral motions by manipulations

Relief of Deformities

The relief of pain is usually the prime interest of an arthritic patient in consulting a medical man Next to that is the relief from deformities Oftentimes the two are associated Again surgery is not to be indiscriminately advised, and the degree of relief that may be promised should be accurately weighed against the suffering and possible danger that must be gone through in obtaining it. Yet sometimes (but not so often as one could wish) something may be done even in apparently hopeless cases to mitigate the difficulty of their position. A case at Cook County Hospital comes to mind, in which a young woman with the rheumatoid type of arthritis had been bedridden for years with practically every joint of her body stiffened A bilateral arthroplasty of the jaw which turned out successfully gave her a change from a continuous liquid diet to real food a change which gave her at least one new interest in life, even though it did not change the condition of her other joints.

Flexion Deformity of Knees

Flexion deformity of the knees is one of the commonest deformities resulting from arthritis which may require surgical interference. This is particularly true in cases of the rheumatoid type. When the knees are flexed to a right angle or less certain difficulties arise which often render open operation necessary In these cases the knees may be flexed to a right angle and there may be a few degrees of motion in the joint to either side of this angle The examination gives the impression that the contractures are in the hamstring tendons They often are contracted but usually the posterior capsule of the knee joint is also involved so that a simple tenotomy of the hamstring tendons fails to give the relief desired The posterior capsule of the knee should be divided as well This is accomplished most easily by an incision on the outer side of the femur just back of the lower portion of the iliotibial band The posterior leaf of this band can be followed to the lower end of the femur and entrance made into the

fixed walking with the cast should be begun. When this can be easily done a removable abduction splint may be substituted for the cast massage and active and passive motion without weight-bearing may be begun, and the support may be gradually left off This operation means a shorter period of disability than is necessary following an arthrodesis

As mentioned previously another field of usefulness for this type of operation is in the metacarpophalangeal joints The type of arthritis in which it is particularly applicable is the atrophic or rheumatoid rather than the hypertrophic. The operation is in effect a type of arthroplasty The distal end of the metacarpal bones is removed and the end of the shaft remaining is rounded off Since this is an operation intended to increase the range of motion as well as to relieve deformity the bony surfaces should be kept well apart during the after-care. This is best accomplished by the use of a banjo splint with elastic traction furnished by rubber bands to each finger As soon as healing is well under way that is in from 10 to 14 days gentle passive movement should be begun to be followed by active motion as soon as possible While not engaged in motion the finger should be kept in traction It has been my pleasure to see cases done by Dr Leven thal at Cook County Hospital in which there was excellent painless motion of the fingers following this operation The restoration of useful motion to the fingers would be quite a boon even though other joints were so badly affected that nothing could be done for them.

Synovectomy

Synovectomy or the removal of the synovial lining of the arthritic joint is an operation of value in occasional cases It is useful in those cases in which the pathologic changes are confined to the synovial membrane and the bone and cartilage do not as yet show pathologic changes These cases are characterized by a thickened boggy condition of the joint capsule This must be distinguished carefully from an effusion into the joint. The basis on which synovectomy seems to give relief is apparently twofold In the first place an irritated sore portion of the joint is removed which is of direct benefit. In the second place joints of this type namely those with thickened boggy synovial membrane may be themselves foci of infection almost as much as infected tonsils Hence the removal of a mass of low-grade infected tissue may give considerable general relief This operation was first advocated by Volkmann for tuberculosis of the knee The knee is by far the most available joint for the operation of synovectomy The joint is opened from the inner side of the patella and the synovial membrane dissected away leaving the joint capsule intact. It should be removed completely from the suprapatellar pouch and the internal and external walls of the joint. The membrane in the posterior pouch will be left

course is particularly true of the hypertrophic type, since it is this form which produces exostoses Many of these exostoses are in situations where they do little or no harm, but occasionally they may definitely limit the motion of a joint. If they are in a situation where there is weight bearing or pressure they may cause pain. An exostosis on the inner side of the head of the first metatarsal bone is a rather common example of the latter If it is large enough to pinch the soft tissues between it and the head of the second metatarsal when shoes are worn, a great deal of pain is produced Another similar example is the subcalcaneal spur, which is not necessarily the result of gonorrhea but often occurs in other types of arthritis Removal of these spurs does not entail any great technical difficulty and does give much relief It must be borne in mind that it has no effect whatever on the pathologic process in the joint itself It is also wise to tell the patient that the exostoses may recur for such recurrences are not uncommon. As to the physical therapy employed afterward contrast baths and massage begun as soon as the skin incision is thoroughly healed have proved most efficacious Carefully graduated early use is indicated, but it must be well controlled

REMOVAL OF ENDS OF BONES

In the class of operations for the relief of deformity may be included the removal of the ends of the offending bones This has a very limited range of usefulness being practically limited to the hip joint, where only one is involved and to the metacarpophalangeal joints. In the hip this operation may be regarded as an alternative to the arthrodesis of the hip previously described Its advantage over the arthrodesis is that a movable hip joint results, which is more convenient for sitting but not quite so good for standing or walking If the head and neck of the femur are removed leaving what may be described as a "broomstick" femur, there is sure to be a very marked limp resembling that of a unilateral congenital dislocation of the hip The limp is produced in the same way that is there is lacking the solid point of counterpressure furnished by the head of the femur against the root of the acetabulum. The limp may be diminished by using the Whitman reconstruction operation as done for ununited fracture of the femoral neck. In this operation the head of the femur is removed and the greater trochanter cut off at its base The femur is then abducted sharply and the stump of the neck placed in the acetabular cavity The amputated trochanter will thus be moved downward along the shaft of the femur below its original position where it is fastened to the shaft A plaster cast must be applied to hold the femur abducted until the trochanter has united in its new position. The trochanter's being displaced gives the leverage by which the muscles attached to it act to fix the pelvis during walking. After about six weeks when the transplanted trochanter should be firmly

six weeks to three months Personally I much prefer to reduce the deformity in this type of joint by gradual reduction by the wedging plaster mentioned previously

There is another type of joint which gives much better results by manipulative methods This is the type of joint in which the arthritis is of moderate grade with not much deformity a little capsular thickening but no effusion in the joint In fact the joint gives the impression of a dry' joint Motion is often limited and is painful The x ray frequently shows very little change from normal It is the type often called traumatic arthritis from its frequent association with trauma A typical example is the painful shoulder joint often appearing after a fall in which the weight comes on the outstretched hand In this type of arthritis manipulation under an anesthetic often gives surprising increase in function In manipulating these joints much care must be taken. The joint should be put through its full range of motion gently and only once. Frequently a grating or snapping will be felt which has given rise to the idea that adhesions are being broken though it is very unlikely that there are actually adhesions between the two surfaces of the joint

After Treatment.—We must remember that with this type of joint we are not usually aiming so much at the correction of deformity as at an increase of function For this reason the after treatment will be totally different The shoulder joint should be supported in an improved position preferably by a splint Each day the joint should be put through its range of motion

Physical Therapy —I have spoken of this type of joint as a dry' joint. The physical therapy should be directed towards stimulating the flow of blood to the joint to aid in overcoming this dry condition. Heat is the most effective way of producing this Personally I prefer wet heat though the dry heat is more easily applied In applying wet heat the dressings must be voluminous The wet application should be covered with rubber sheeting and the hot water bag should be applied over *this to keep the dressing hot. The use of an ordinary electric* pad with hot wet dressings is unsafe though there are now electric pads specially devised for this use The skin should be guarded against maceration and hot dry cloths should be applied after the removal of the wet dressing to prevent chilling of the part. Massage is useful in these cases Again the object of the treatment should be kept in mind. This indicates stimulating massage rather than sedative The massage should be deep in order effectively to increase the flow of fluid to the joint. But the most important part of the physical therapy is the active motion of the affected joint Nothing stimulates a dry joint so well as its natural function. This must be carefully guarded in the beginning but should be kept up to the limit of tolerance It is with this type of dry' joint that the so-called bonesetters have their remarkable results

After Treatment.—After the operation no immobilization other than that supplied by the usual dressing should be used, since it is desired to obtain motion. The quicker motion can be obtained, the better Hence, gentle active and passive motion should be begun as early as two or three days after the operation, but it must be gently done. Heat applied to the joint hastens absorption of exudate following the operation Function of the joint should be resumed as soon as possible though time will vary with individual cases Key has found that after the removal of the normal synovial membrane from a rabbit joint it is reproduced in about 60 days This of course, was the case with the normal membrane, which may act differently from the diseased, but at any rate it is possible for the synovial membrane to be reproduced intact.[1,2]

Manipulative Surgery

Another type of surgery sometimes used in cases of arthritis is manipulative surgery This has a field of usefulness but it has also its dangers As a matter of fact, in genuine arthritis, particularly of the atrophic type it has almost no field. In this type of arthritis the deformities are caused by contraction (associated with thickening) of the joint capsule and to a certain extent of the tendons and muscles about the joint. There is also associated with this a marked thinning of the bones shown by a loss of their mineral content. If, then we undertake to manipulate such a joint under an anesthetic, we are confronted with several dangers One is the danger of producing a fracture either a transverse fracture of one of the bones forming the joint, or a crushing fracture of the joint surfaces of the bones Atrophied bone crushes with very slight pressure almost as easily as ordinary pasteboard, and will often do so more easily than the contracted capsule or tendons will stretch. Another danger is injury to blood vessels or nerves. For instance, if a knee has been flexed for years to a right angle or less the arteries and nerves are likely to have undergone adapted shortening and violent stretching will either rupture them or narrow the lumen so as to interfere seriously with the blood supply For these reasons in a joint of this type the temptation to try forcible correction under an anesthetic should be resisted If it is done it must be done gently The force must be applied gradually so as to permit slow stretching of the contracted tissues and excessive force must not be used. To define excessive force in terms of pounds is quite impossible. Furthermore it must be remembered that all bones and joints are types of levers, and the force that one applies to a bone may be multiplied many times by the lever action Each joint must be a law unto itself In attempting to reduce the deformity of a stiff joint by manipulation it is to be remembered that the deformity is extremely prone to recur Hence it should be placed in a plaster cast and held in the corrected position until there is no tendency to relapse This will be a long time from

six weeks to three months Personally I much prefer to reduce the deformity in this type of joint by gradual reduction by the wedging plaster mentioned previously

There is another type of joint which gives much better results by manipulative methods This is the type of joint in which the arthritis is of moderate grade with not much deformity a little capsular thickening but no effusion in the joint In fact the joint gives the impression of a "dry" joint Motion is often limited and is painful The x ray frequently shows very little change from normal It is the type often called traumatic arthritis from its frequent association with trauma A typical example is the painful shoulder joint often appearing after a fall in which the weight comes on the outstretched hand In this type of arthritis manipulation under an anesthetic often gives surprising increase in function In manipulating these joints much care must be taken The joint should be put through its full range of motion gently and only once Frequently a grating or snapping will be felt which has given rise to the idea that adhesions are being broken though it is very unlikely that there are actually adhesions between the two surfaces of the joint

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Preventive Surgery

There is still another resource which is available in the surgical treatment of arthritis It lies somewhere between active surgery and physical therapy It may be called preventive surgery I have said previously that active surgery is rarely if ever, indicated in the active stage of arthritis Yet it is in precisely that stage that most can be done to prevent the troublesome deformities which may later require active surgical intervention

Immobilization.—During the acute stage of an arthritis the affected joints are very sore so that the least motion causes pain During this stage of soreness immobilization gives most grateful relief and can be made to subserve the purpose of preventing deformities. Immobilization may be accomplished in various ways, all of which have the same object in view

Casts —The first is by circular casts. A cast applied to immobilize the affected joints should extend far enough above and below the joint to render immobilization complete. For example, a cast applied to the knee and extending only five or six inches above and below it is a very ineffective method of immobilization and will not give the desired relief It should extend at least from the groin to the ankle and it is better for it to include the foot. Similarly, if the elbow is the joint affected the cast must extend at least from the shoulder to the wrist If it is the hip or the shoulder, the cast must include practically the entire trunk The joint to be immobilized should be placed in the position which will produce the least inconvenience if it should remain stiff either permanently or temporarily These positions are as follows for various joints first, for the shoulder abduction should be to nearly 90° with the humerus at an angle of about 45 to the lateral plane of the trunk Second for the elbow there should be 90 or a little less for the right and a little more than 90° for the left if the patient is right handed Third the wrist should be dorsiflexed about 40 since this position allows the fingers to flex easily Fourth, the hip should be placed in the lateral plane of the body and abducted about 10° With regard to the hip this position is open to some argument. It is the best for walking or standing but it is inconvenient for sitting. A few degrees of flexion 15° or 20°, make sitting much more comfortable and do not interfere much with walking It is to be remembered also that the types of arthritis being considered very rarely result in complete bony ankylosis so that some motion will frequently be developed later which is useful if it is painless Fifth, the knee should be immobilized in a straight line but never hyperextended. In order to prevent this the limb should be supported both at the ankle and the knee while the cast is being applied. Sixth, the ankle should be immobilized at a right angle to the tibia with the foot neither

pronated nor supinated Inasmuch as arthritis only occasionally affects a single joint various combinations will have to be worked out with the above principles in mind The disadvantage of a circular cast for immobilization in acute arthritis is that it precludes the use of any of the other therapeutic agents such as heat, etc. This may be avoided by splitting the cast on each side while it is still wet. The anterior half can then be removed for inspection of the joint or application of heat and replaced after that treatment is finished. In this way both the benefits of the immobilization in the prevention of deformity and the physical therapy can be combined It ought to be remembered that the actual therapy takes a comparatively short time each day and that much of its effect can be lost during the remainder of the 24 hours

Traction —Another form of immobilization that is useful is traction. During the acute stage of arthritis there is much spasm brought about by friction of the sore joint surfaces on each other This muscle spasm is apparently nature s effort to immobilize the sore joint. Traction acts by drawing these sore surfaces apart and so reducing the friction in the joint. It has this advantage over the simple immobilization by casts or splints The use of traction by adhesive plaster is so well known that it is not necessary to describe the method However there is one detail which is overlooked at times and which greatly diminishes the effectiveness of the method That is that the adhesive should never be applied beyond a point four or five inches below the joint on which traction is being made. If it is placed higher than that, the traction is exerted mainly on the skin above the joint with little benefit except from the immobilization of the joint. Of course in the discussion of prevention of deformities by immobilization by casts or traction it must be understood that this applies to those in the acute stages who are still bed patients

Conclusion

In closing the chapter I wish to reiterate most emphatically that operative surgery is not advocated for every case of arthritis no matter what the type or whose classification may be followed Surgery in arthritis will always occupy a distinctly back seat (although al ways" is an extremely dangerous word in medical science) Nevertheless many arthritic patients have been distinctly benefited by well judged surgery There is no field of surgery which calls for finer judgment not alone of the physical condition but of human nature Each case must be carefully individualized not only with regard to the patient s specific condition but as to his general condition and his mental reactions as well He must be willing and able to put much effort into his own after treatment All the other resources of medicine and physical therapy should be thoroughly tried before considering

surgery But if surgery must be done, "more power" to the surgeon and the patient

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CHAPTER FIFTEEN

PHYSICAL THERAPY IN THE TREATMENT OF BRAIN AND SPINAL CORD LESIONS

LOYAL DAVIS M.D AND JOHN MARTIN M.D

The treatment of lesions of the brain and spinal cord should be directed toward the restoration of the patient to a normal life of social and economic independence The physician frequently makes the error of looking with an attitude of hopelessness upon the disabilities which result from injury or disease of the central nervous system. The result of this fatalistic outlook may be a life of invalidism for the patient, with physical and financial dependence upon his relatives or community There is no doubt but that many of the crippling deformities and contractures which commonly result from cerebral and spinal cord involvement could be partially or wholly avoided by a well-directed regime of physical therapy

CEREBRAL LESIONS

The paralysis which results from disease or trauma of the cerebrum is always spastic in character Quite commonly the paralysis may at first be flaccid with the absence of all the deep tendon reflexes but eventually an increase of tone develops in the muscles of the affected extremities and this change is accompanied by other signs and symptoms of an upper motor neuron lesion. Briefly these are increased deep tendon reflexes absent superficial reflexes the presence of pathologic reflexes (such as the Babinski, Oppenheim Gordon and Chaddock signs) absence of muscle atrophy and absence of the reaction of degeneration. The motor loss which occurs as the result of a cerebral lesion is in most instances hemiplegic in nature although spastic monoplegias and diplegias also occur In the hemiplegic type the arm is commonly much more affected than the leg, while the face is paretic in various degrees in different cases

The most common lesions which produce cerebral spastic paralysis are (1) cerebral vascular accidents (hemorrhage thrombosis embolism) (2) intracranial space-occupying lesions (tumors abscesses) (3) cerebral palsy or "diplegia" of childhood (4) traumatic lesions of the brain and (5) inflammatory diseases of the brain or its meninges (meningitis encephalitis)

Etiology —VASCULAR LESIONS —Cerebral vascular lesions rank first as the most common cause for all the hemiplegic states Following an arterial hemorrhage or an embolus the onset of symptoms is sudden and acute. The symptoms of a thrombosis are more gradual and in

sidious in their development If death does not occur during the first three weeks following a cerebral hemorrhage, improvement in the paralysis uniformly appears and may be progressive for many months. Most frequently the leg will show the first signs of improvement and this is followed by the face, while the arm being the most severely involved is the last to show a return of function At first the reflexes are absent or greatly depressed and the muscles are correspondingly limp and flaccid Gradually the reflexes increase and finally become exaggerated. Rigidity and stiffness appear in the paretic extremities and foreshadow the contractures which will later develop Such contractures are always much more severe in the upper extremity than in the lower The flexor muscles predominate over the extensor in the arm so that the fingers become drawn into the palm of the hand, the wrist is strongly flexed the forearm is fixed in pronation, and the elbow is semiflexed With all the joints thus flexed, the entire extremity is held close to the side of the chest. If the fingers, wrist and elbow are forcibly extended by the examiner and then released, they fairly snap back into their former position If allowed to remain unchanged in these attitudes the joints become ankylosed muscles and tendons become rigid and contracted, and deformities result which rapidly become irreparable Passive manipulation of such an extremity is quite painful to the patient In the lower extremity rigidity of the muscles develops in the position of extension The knee is extended rigidly, and there is a tendency for the foot to assume a position of equinovarus. Thus the distal segments of both the upper and lower extremities are affected to a greater degree In the presence of marked contractures the limbs are moved as a whole by the muscles of the pelvic and shoulder girdles with little or no motion of the individual joints of the extremities In walking the weight is carried upon the sound leg, and by the trunk and pelvic muscles the paralyzed extremity is swung forward the toe dragging in an arc-like course around the heel of the unaffected foot. This is the typical circumduction' gait of the hemiplegic patient.

Evidence of circulatory disturbance may be quite marked in the paralyzed arm or leg At first the limb appears red and cyanotic perspiration may be profuse the skin may become soggy and macerated. Growth changes may appear early in the hair nails and skin Eventually the skin temperature of the affected extremities is much lower than that of the unaffected side so that the weakened extremities may actually feel cadaveric to the touch. While trophic changes in the early stages of a hemiplegia are not common an acute decubitus lesion may develop any place on the affected side especially as the result of prolonged pressure, and ulceration in the palm may occur from the severe pressure of the nails of the rigidly flexed fingers. When the muscles atrophy it is because of disuse Electrical examination shows a normal reaction of the muscles and peripheral nerves to the faradic and galvanic currents.

The paralyzed hand may suddenly open or the spastic leg become

flexed quite independently of any voluntary effort. Following such instinctive actions as yawning sneezing or stretching the entire upper extremity may be raised over the head Or if the patient attempts to close and open the sound hand similar abortive movements may occur on the paralyzed side. These associated movements and certain athetoid phenomena must be evaluated properly to avoid the false assumption that they signalize the return of voluntary movement in the paralyzed limbs

Space-Occupying Lesions —The paralyses which develop as the result of intracranial tumors or chronic abscesses are also of the upper motor neuron type However if they are small enough or well enough localized to one small functional area of the cerebral cortex, they may involve only one extremity upon a side Moreover the development of the paralysis is more gradual and quite frequently the patient is able to trace the successive involvement of the face arm and leg In contra distinction to the hemiplegia caused by vascular accidents the involved extremities rarely exhibit the initial stage of flaccidity because the onset of the paralysis is usually less acute However in the presence of a tumor or an abscess the muscles are ordinarily spastic and rigid from the beginning An exception to this may be made in the uncommon event that a sudden hemorrhage occurs within a tumor mass The resultant massive insult to the cerebrum may then be so great that a flaccid hemiplegia or monoplegia results later becoming spastic. Convulsive seizures in the involved extremities (of localizing value) or repeated tonic spasms are common irritative phenomena which accompany intracranial space-occupying lesions In all other respects the paralyzed extremities exhibit the same characteristic symptoms that have been described in the more acute hemiplegic state

The surgeon who successfully removes an intracranial tumor which has produced a hemiplegia has only partially fulfilled his obligation to the patient Every possible means should be exhausted in the attempt to restore the use of the arm and leg by the many possibilities of physical therapy

Cerebral Palsies of Childhood —Spastic diplegia (also called Little s disease) is the most common form of congenital cerebral paralysis although hemiplegias and monoplegias also occur In the hemiplegic or quadriplegic types the arms are commonly affected more severely than the legs. More frequently than not such a condition is associated with a mental defect or with epilepsy The severe forms are obvious at birth but milder cases may not show definite symptoms before the age of six or seven months Grossly the brain is usually small and there is sclerosis and cortical atrophy on one or both sides In Collier's words it is a small primitive type of brain destitute of neurones "[1]

In some children suffering from this condition the rigidity and spasticity are so great that the extremities present a lead-pipe resistance to passive movements of any sort. The spasticity in the lower extremities

tends to flex the hips and knees, and to adduct the thighs until the knees are held so close together that it is difficult to bathe and dress the patient If the child is placed in a chair, the rigid lower limbs remain unsupported in a horizontal position. When the patient is placed upon his feet, the legs cross, the heels fail to touch the floor, and walking is impossible. As the child grows older there is a tendency for the development of an equinovalgus or equinovarus as well as a genu valgum. Some patients manage to keep the feet widely separated so that a shuffling gait, with toes scraping along the floor, is accomplished. In the milder forms of the disease the patients exhibit only slight spasticity of the legs, so that there is only a tendency to walk on the toes.

Many such children develop involuntary athetoid or choreoid movements in the hand, usually from nine months to two years after the onset of symptoms Such movements become very complex and may be intensified and accompanied by involuntary grimacing upon voluntary attempts to move the limb When the patient tries to grasp an object, the fingers are hyperextended and widely separated. The hand approaches the object in a clumsy, slow, awkward, and poorly controlled manner These movements may even become so serpentine that the patient s arm winds about his neck or back. In the majority of cases these vigorous involuntary movements appear only when stimulated by voluntary effort or by some emotional disturbance, and though they are purposeless they are useful in keeping the muscles in a good state of nutrition. Associated movements which occur when the paralyzed extremity attempts to follow the healthy limb are more marked and bizarre in these cases than in the hemiplegias which have been described previously

Contractures in the extremities develop rapidly, just as in the spastic paralysis due to vascular lesions so that grotesque attitudes may result. The low mentality of the patients, and such complicating factors as blindness and epilepsy seriously influence the treatment, since therapy must be directed toward the mental state by special tutoring until such a time as the brain can be assumed to have attained its full and definitive development.

TRAUMA.—The commonest forms of trauma to the cerebrum are gunshot wounds and depressed or comminuted fractures of the skull. The former constitutes a common lesion in time of war while the latter is frequent in civilian life following automobile accidents. Such injuries involving the motor cortex cause a spastic paralysis that is usually hemiplegic or monoplegic in form, and indeed the injury may be so discrete in the brain as to cause quite an isolated paralysis of some part of the body Recovery from the initial cerebral damage in this group of cases offers a good opportunity for the active treatment of these patients by physical therapeutic means Here, again the paralysis is of the upper motor neuron type with spasticity of the involved extremities and increased deep tendon reflexes similar to those seen in the lesions previously described. Failure to institute adequate treat

ment results in the development of contractures and ankylosed joints which deform the extremity beyond hope of returning the individual to a useful position in life Other injuries occurring at the same time as the cerebral trauma may require prolonged hospitalization such as a fracture or an osteomyelitis from a badly soiled compounded frac ture and contractures may even develop while such complications are being taken care of if physical therapy is not instituted at the proper time in the handling of the paretic extremities

The disabilities arising from these lesions are due to direct injury of the brain or occur as the result of subsequent infection Early and thorough surgical treatment of these wounds with adequate débridement and primary closure affords the best method of securing rapid healing with a minimum of eventual motor loss Of recent years the derivatives of sulfanilamide have been of great aid in controlling the infections which tend to develop in such wounds The residual loss of function in traumatic lesions of the brain depends of course upon the exact site of the injury It is not uncommon to observe complete paralysis of the upper and lower extremities as the result of an injury to the frontal or occipital lobes some distance from the motor cortex. One patient, J.A. was struck by an automobile and sustained a comminuted skull fracture over the posterior parietal area, and when the wound was surgically cared for 35 or 40 grams of cerebral tissue macerated and mixed with hair and street dirt, were removed from the wound along with fragments of bone The cortical injury was well posterior to the sensory area of the right cerebral hemisphere yet the man suffered a paresis of the left side of the face and left upper ex tremity with only slight loss of position sense in that limb He later developed typical Jacksonian seizures involving the left side of the face and the left arm In such instances however unless there has been actual injury to the precentral area of the cortex one may expect with some confidence to see a gradual disappearance of the paralytic symptoms. Immediate and severe paralysis which is more commonly hemiplegic in character, results from direct injury to the motor cortex. At first this paralysis is flaccid with abolition of all reflexes Soon however there is an increase of tone such as has already been described in the hemiplegic state. The deep tendon reflexes become in creased well marked spasticity develops and if active treatment is not instituted, contractures and malpostures appear

Inflammatory Lesions —When either an acute or low grade in flammatory process becomes established in the meninges and subarachnoidal spaces of the brain there may result a spastic paralysis which differs in no way from that described following other cerebral lesions While immediate recovery from meningitis is now less problematical than it formerly was due to the use of sulfanilamide and its deriva tives it is not at all uncommon to see paralytic sequelae follow recov ery This is also true of encephalitis The paralytic complications of both of these inflammatory lesions are more common in children than

they are in adults They are both accompanied frequently by convulsive seizures which are commonly jacksonian in type. These latter may be so frequent that a true status epilepticus develops It is interesting to note that in these cases the cortical tissue may become very sclerotic, hard and firm, so that a ventricular needle is introduced with some difficulty and with the sensation of passing it through hard, sandy soil.

Clinically, the children who have suffered from encephalitis and then develop spastic paralysis are much like those children who have had spastic palsy from birth While the paralysis in the latter instance is more commonly due to hemorrhages (frequently of a widespread interstitial type) which occur during birth, the former paralysis may develop as the result of an infection at any time. In contrast, also, their mentalities may be quite normal The spasticity of their extremities and the deforming contractures of their hands and feet are similar in all respects

TREATMENT OF LESIONS RESULTING IN MOTOR DYSFUNCTION

The widespread feeling that recovery from the paralysis of a cerebral lesion was impossible has been responsible to a great extent for the lack of concerted effort toward the continued treatment of these patients In 1915 Franz, Scheetz and Wilson [2] called attention to the fact that the conclusions regarding the permanency of paralysis from cerebral accidents were neither accurate nor based upon scientific principles They pointed out the striking improvement which could be effected by careful and persistent attention to this group of cases.

In general, the treatment of the paralysis resulting from cerebral lesions may be divided into that which is used immediately and that which may be employed later in the course of the lesions

There is little doubt that complete mental and physical rest for a prolonged period is one of the most important steps in the treatment of cerebral damage regardless of its etiology By rigid enforcement of this treatment, the cerebrum may be given every opportunity to recover its normal function as much as possible. Particularly in vascular accidents such a method of treatment will aid in preventing what may be a fatal recurrence Good nursing with careful attention to the skin of the back and buttocks will prevent the development of decubitus sores which may be very difficult to heal and may impede the application of physical therapy Attention to the bladder, which may distend and overflow will often prevent the extreme restlessness exhibited in traumatic cerebral cases. The patient s position must be changed frequently particularly the aged if the development of "wet lungs" or frank pneumonia is to be avoided Dehydrating agents such as 50 per cent sucrose administered intravenously should be used judiciously in the acute phase of trauma or cerebral vascular accidents, as well as after the surgical removal of certain tumors in the effort to keep brain swelling at a minimum Spinal punctures are useful in the early stages of the treatment of traumatic lesions and when done carefully with

manometric control they not only drain off the bloody spinal fluid which acts as an irritant and causes restlessness but they also offer the best means possible of keeping patent the absorptive mechanism in the cerebrospinal fluid spaces the arachnoidal villi

Paralyzed Extremity —The adoption of measures to insure rest should in no way interfere with the early treatment of the paralyzed extremity Gentle massage of the muscles of the involved extremities should be instituted as early as possible after the shock of the original trauma has disappeared This may be associated with mild faradism to provide gentle exercise of the muscles The chief concern of the nurse should be to prevent the helpless extremities from remaining in a fixed position Often bedclothes are allowed to rest upon a paralyzed foot so that it is forced and held in a position of footdrop A cradle which will keep the weight of the bedclothes off the extremity and yet *will allow freedom of movement of the sound limb may be made very* simply Passive movements of all the joints and in all directions should be carried out very gently and should be repeated several times each day

Splints —The employment of light but effective splints to correct the tendency of a segment of an extremity to assume a malposition is important. The heavy permanent type of splints however may do more harm than good For example the use of a light crinoline posterior molded splint which is well padded will be just as effective in keeping the foot in a correct position at right angles to the leg as will a heavy cumbersome plaster-of Paris splint As a matter of fact, pillows and sandbags may be used in a very effective manner to prevent deformities The important objects to be obtained are frequent changes of position and the prevention of overstretching of paralyzed muscles.

Splints are not so satisfactory in old neglected cases of spastic paralysis as they are in cases of flaccid paralysis. However they may be employed judiciously to help overcome long-standing deformities Temporary splints should be devised which employ elastic tension else the harm from oversplinting may interfere seriously with their efficiency Each splint should be constructed to meet the individual patient s need and to help him obtain the most satisfactory results An easy way in which to procure such simple splints adapted to the special need of the patient is to fashion them from sheet aluminum or other malleable metal with hand metal-cutting shears Such splints, properly molded and padded are quickly and inexpensively made Here again however too much tension must be avoided since it is undesirable to excite reflex muscle contractions which would defeat the purpose of the splint.

Voluntary Movement —As the patient begins to recover voluntary power will return in the proximal muscles of the hemiplegic extremity and the increased tone of the muscles will be apparent. At this time the patient s help must be sought. He should be told that the ultimate degree of recovery of function depends to a great extent upon

they are in adults They are both accompanied frequently by convulsive seizures which are commonly jacksonian in type. These latter may be so frequent that a true status epilepticus develops. It is interesting to note that in these cases the cortical tissue may become very sclerotic, hard and firm, so that a ventricular needle is introduced with some difficulty and with the sensation of passing it through hard, sandy soil.

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It must be emphasized that the personal attention and care of a trained physical therapist can never be replaced or improved upon by any kind of mechanical device The therapist not only exercises pa tience and human understanding but is able to adapt herself and her physical agents much more to the patient s needs than can ever be expected of a machine. The ideal combination obviously is composed of trained hands and good mechanical equipment.

ACTIVE MOVEMENTS —Even though marked contractures are present in late neglected cases usually active movements are possible in some degree or other in the affected extremity The patient should be encouraged to practice these movements daily many times It is often necessary to associate them with simple purposeful acts, so that the patient s interest and enthusiasm may be held. Above all he must be completely relaxed and at ease during these periods of practice. No attempt should be made to use a spastic muscle until it is relaxed. The patient should sit erect, but at ease beside a table of correct height. The elbow and entire forearm of the flexed extremity should rest on the table. Relaxation of the elbow wrist and hand is then possible. It is common to observe a hemiplegic patient perform movements which he is wholly unable to repeat upon command or in the presence of strangers but he must not be allowed to develop a defeatist attitude and he must be told that failure to perform his exercises properly is no cause for discouragement The tasks to be accomplished must be increased slowly and patiently and he must be made to believe that his recovery depends largely upon his own attitude

The use of simple mechanical devices is perhaps the most valuable method of obtaining active exercise of muscles This routine of muscle education should be planned to utilize and develop the intact residue to the highest degree of efficiency Purposeful occupations and play center the patient s attention upon his accomplishments rather than upon his disability While the spastic patient may be able to perform given exercises it is well to show him by means of occupational ther apy that such movements may be quite practical This is most impor tant in cerebral palsies of childhood in which of course the treatment is limited in extent by the mentality of the child under treatment.

While gross arm or leg movements may be accomplished rather quickly the hands and fingers recover far more slowly and are more obstinate in their resistance to treatment Franz and his co-workers found that one of the simplest and most effective exercises was to have the patient attempt to open the fingers after a ball was placed in the hand. An elastic rubber ball is perhaps the best such object to use At first this act may be almost impossible but soon the patient may be able to perform such a movement and pick up the ball as well The time required to grasp and release a ball may be used as an accurate record of the patient s progress Attempts to draw a straight line with a pencil to sort colored glass beads to arrange wooden blocks to solve jigsaw puzzles to use a fan (this develops pronation and supina

his enthusiastic and persistent co-operation He must not be allowed to lie in bed with the paralyzed arm flexed and folded across his chest. He should place it away from his body, fully extended, and with the hand supinated As passive movements are instituted, he should be asked to attempt each individual movement with each performance and to hold the segment in the position into which it has been moved passively The arc of the movement should be completed each time a passive movement is employed

The patient should be closely directed from the beginning of the return of the first voluntary movement. The tendency is for him to keep repeating that particular movement to the exclusion of all others. He should be taught to attempt new movements and to persist in those attempts whether or not they are at first attended by success. It is well for him to practice simple purposeful movements such as he would ordinarily perform in his daily duties, such as dressing himself, handling his own food at table writing and receiving objects of various kinds into his hands. The ability to keep him from becoming discouraged may account for success or failure and if his movements accomplish a purpose his interest and courage will be maintained.

Massage Vibration, Heat —In spite of the most carefully directed methods of early treatment in cases of upper motor neuron paralysis spasticity and rigidity of the muscles will tend to develop because of the inherent nature of the lesion Consequently, more strenuous methods of treatment to prevent deforming contractures and joint ankylosis will become necessary

Unfortunately most patients who have received cerebral damage present themselves for treatment after spasticity and rigidity of the muscles and deforming contractures have developed. In the presence of marked spasticity incorrectly employed massage not only may be useless but may increase the rigidity Spastic extremities exhibit heightened reflexes Knee and ankle clonus may be elicited by the slightest stimulus The lightest touch to the lower extremity at any point may produce a marked withdrawal defensive reflex of the entire limb Therefore massage should be very light and should consist more of stroking than of rubbing Franz was able to reduce the hypertonicity considerably by vibration In this maneuver the hand is grasped and the arm is shaken or vibrated gently until a distinct loosening of the muscles has been noted. Dry heat before massage is begun is of distinct aid in securing this reduction of hypertonicity but in our experience immersion of the limb in a gentle warm, whirlpool bath has been more effective. However employed, heat improves the circulation to these extremities which are colder than the normal limb

Because of the increased reflex activity in these limbs, electrical stimulation of the muscles in the late stages of treatment is in general, contraindicated If mild faradization can be used without exciting reflex movements of the muscles it may help to provide active gentle exercise for the muscles which are inactive.

ning the patient must be encouraged to practice assembled and co-ordinated exercises designed to teach him the proper way to walk. He must not be allowed to walk in the manner easiest to him (circum duction of the entire leg without flexion of the hip or knee) without making an effort to correct it. He should not be allowed to watch his feet, in order that he may more quickly reflexly control his balance. He should be made to support his own weight and maintain his own balance as completely as possible Rubber soled shoes and a rubber cap on his cane will add greatly to his feeling of security

PASSIVE MOVEMENTS —Passive movements of all joints should be performed patiently and carefully by someone trained in such work and who has a knowledge of the anatomic parts involved These movements may be quite painful at first and therefore must never be done in a violent manner and force and determination cannot be used to overcome a spastic muscle At the same time the patient must be taught to perform passive movements by himself with the aid of his sound extremity and this he can do while sitting quietly alone without other occupation. In this manner the joints may be kept supple so that when active attempts are made the joints can be moved

Report of Cases.—The following brief report of two cases will serve to illustrate the problems which one encounters and the results which may be obtained in the treatment of this group of patients

W R. (Fig 1) aged 40 fell off a fast moving truck and struck his head upon the concrete pavement. There was an "egg-shell" fracture of the right parietal bone The patient was unconscious for twelve hours. When he recovered from his coma complete flaccid paralysis of the left arm and leg was observed. Eighteen hours later the lower half of the left side of the face was involved.

It was felt that there were no surgical indications present The patient was treated by hypertonic solutions. The period of flaccidity remained for ten days before a gradual increase in tone was noted During this time gentle massage of the arm and leg was given as well as passive movements of all the joints. The left foot was kept at right angles to the leg by the use of sandbags and pillows.

As spasticity developed, the arm tended to flex across the chest. This was kept abducted and extended by the use of sandbags and pillows at night. During the day passive movements were carried out in all of the joints throughout their entire range of movement. At the same time the patient was encouraged to attempt the same movement voluntarily

The first return of voluntary movement was noted in the face after three weeks and this was followed rapidly by movements of the upper arm and then by movements of the fingers. Active movements of the leg returned last of all because the motor cortex near the vertex was contiguous to the site of the fracture When the patient was able to be out of bed after six weeks, definite purposeful exercises were instituted for the arm and leg Graduated exercises and persistence with determination on the part of the patient resulted in a most satisfactory return of function after a few months so that the patient was eventually able to return to a normal life with a minimum of permanent disability

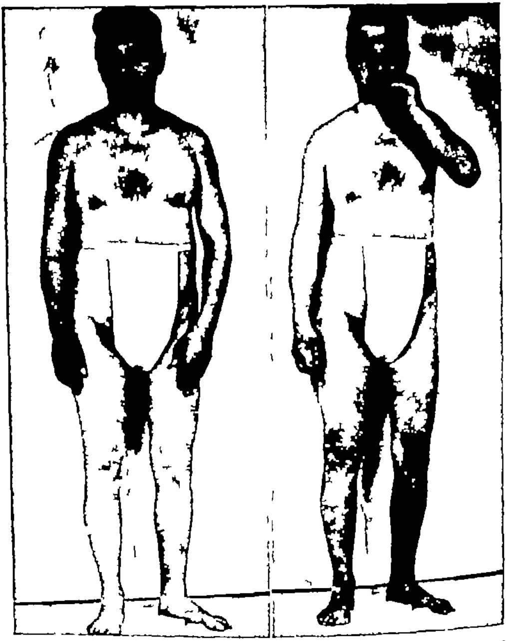

Fig. 1—Posttraumatic hemiplegic patient after six months of intensive physical therapy He was able to walk when discharged from the hospital seven weeks after injury and f r ver six months he was treated by massage active and passive motion, and graduated re-educational exercises. When last seen eleven years after his accident he was entirely well except fo a slight residual spasticity in the left hand.

tion) to "climb a small wooden ladder with the fingers and to use a needle and thread are several simple methods of developing smoothly coordinated movements of the upper extremity Similar simple active exercises may be devised to re-educate the muscles of the lower extremity No attempts to move the lower limb should ever be made when the patient is not at ease and well balanced. From the begin-

various types of aphasia or of the anatomic location of the cerebral lesions responsible Many simple exercises may be devised to re-educate these patients based upon the description of the various types of aphasia given by Head [3]

Verbal Defects — In severe forms of this disorder the patient s utterance may be reduced to 'yes and 'no and even these words can not always be evoked or voluntarily used. As speech returns his vocabulary increases but his enunciation is slow and halting Any word he is able to recall can however be used for naming an object. It may be so badly pronounced that it is scarcely recognizable but it is applied correctly When the patient attempts to repeat what has been said to him the articulatory words are imperfect although he can usually repeat more words than he can pronounce spontaneously It is characteristic of this form of aphasia that words are evoked with difficulty and tend to be abnormal in structure

' At first the comprehension of verbal significance may be somewhat impaired. But, after the stage of neural shock has passed away the power of understanding the meaning of words is rapidly restored these patients can not only choose an object to oral or printed commands but even complex orders may be executed correctly

'The power of reading to themselves with enjoyment is spoilt by difficulty in remembering a series of words accurately they are frequently compelled to look back to the beginning of a long sentence in order to obtain its full meaning On the other hand reading aloud is hampered by the same defects as articulatory speech.

As the spoken vocabulary increases the power of writing is regained although throughout it tends to show the same errors as articulatory speech These patients cannot spell and find difficulty in remembering the order of the letters even in simple words They write more easily to dictation but are unable to carry in the memory a string of words or a long phrase Ability to translate printed words into cursive script, though at first diminished is as a rule rapidly recovered."

Syntactical Defects — 'This is an easy form to distinguish, because the patient tends to talk jargon. Not only is articulation of the words ill balanced but the rhythm of the phrase is defective, and there is want of grammatical coherence The power of naming objects may be retained in spite of the gross defects by which speech is hampered. Not infrequently when the patient cannot utter a name or when the sound emitted is incomprehensible to his auditor he writes it correctly proving that he is familiar with the usual designation of the object

"Comprehension of the meaning of words is always in excess of their use in conversation These patients can choose common objects or colors without fail to oral commands in the form of a single word if however the order is conveyed in a spoken phrase it may not be

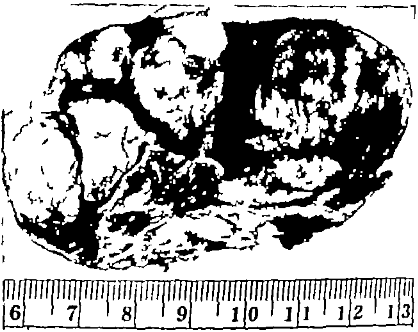

FIG. 2.—Photograph of a fibroblastic meningioma, weighing 98 grams, removed from the right frontoparietal area of the cerebral cortex in a man with a complete left hemiplegia. Following its removal, physical therapy was instituted and in less than five months the man was restored to his former occupation as manager of a shoe store.

L. W aged 33 was operated upon and a fibroblastic meningioma (Fig 2) weighing 98 grams, was removed from the right cerebral hemisphere. The motor cortex lay directly under the tumor as was attested by the patient's history of epileptiform seizures and left sided weakness. Following total removal of the tumor the patient was in every way improved except that his motor weakness was somewhat increased and with it there developed a spasticity of the muscles which appeared within a few days postoperatively. Though the patient was at first not co-operative and disliked any sort of passive manipulation, physical therapy treatments were started as soon as he could be taken to the physical therapy department of the hospital. There heat, massage passive and active exercises were instituted with remarkable success. With continued urging the patient stopped favoring the left hand and used it for purposeful movements gained sufficient confidence to walk with less support using a cane and became able to swing the left upper extremity at his side when walking with all normal associated movements. In this man's case not only was good physical therapy needed and used, but a proper mental attitude and understanding of the problem had to be developed within the patient himself and with each little improvement his enthusiasm mounted

Speech Defects.—Lesions of the left cerebral hemisphere in right handed individuals or of the right cerebral hemisphere in left-handed individuals may be accompanied by aphasia. This is particularly characteristic of vascular lesions and is less common in intracranial tumors or following trauma It is unnecessary to enter into a discussion of the

ciation of meaning and inability to evoke a desired name both internal and external speech suffer as a secondary result

Such patients read with extreme difficulty both to themselves and aloud especially if they attempt to spell out the words Single letters even if correctly enunciated frequently fail to convey their full nominal significance Printed orders are badly executed but to read them aloud is a decided aid to their correct performance

Both the act of writing and the power of conveying the intellectual content of ideas evoked spontaneously or in response to something heard or read are greatly affected. Writing to dictation shows the same calligraphic faults although the subject matter is somewhat better reproduced and in the severe forms these patients slavishly copy printed or cursive letters but cannot consistently translate print into ordinary handwriting

'They can usually count but suffer from defective appreciation of the meaning of single numbers This interferes with the power to carry out simple arithmetical operation and capacity to formulate the relative value of two coins or to calculate change is usually more or less affected Games such as cards which demand rapid and correct recognition of names and power to register a score are impossible On the other hand chess draughts and dominoes may be played correctly

'Drawing from a model or from memory after the object has been removed from sight, is easily performed But, when the patient is asked to draw some such figure as that of an elephant from imagination, the result is extremely unsatisfactory all the distinctive features are usually omitted.

'He can usually find his way from place to place so long as distinctive landmarks are in sight, but he may have considerable difficulty in planning his route beforehand or in describing the salient objects he would meet on his journey One of the most instructive forms assumed by the loss of function in these cases is the want of ability to draw a ground plan of some familiar room. Asked 'Where is the table? or 'Where is the window? he can point to the situation of each correctly but he cannot express their relative position in the abstract form of a ground plan Moreover, he tends to slip into an attempt to express the principal pieces of furniture in elevation evidently reproducing his concrete visual images.

Semantic Defects —"This form of aphasia is characterized by want of recognition of the ultimate significance and intention of words and phrases apart from their direct meaning. But other functions suffer that have no immediate bearing on verbalization for in this form of disordered speech there is loss of power to appreciate or to formulate the general conclusion of a connected train of thought. The patient may understand a word or short phrase and can appreciate the various details of a picture but the significance of the whole escapes him Thus although he comprehends the meaning of summer'

understood correctly In daily intercourse they suffer from inability to recall with certainty what they have been told, not only is phrasal utterance defective, but phrasal memory is transitory This makes consecutive conversation difficult or impossible, and leads to an apparent slowness of apprehension

"Such patients can understand what they read to themselves, provided they are not compelled to reproduce the meaning in words either silently or aloud, for their internal speech is also disturbed by jargon.

'Single words may be written correctly, but any attempt to convey a formulated statement in writing is liable to end in confusion. Patients suffering from the more severe degrees of this affection cannot write a letter but in slighter cases writing is easier than articulatory speech, and all of them can copy correctly transcribing print into cursive handwriting

"Counting and the use of numbers is not materially affected, except that the pronunciation of the actual numerals is liable to be defective. There is no difficulty with the manipulation of money, or in giving the names and relative value of coins

"These patients can understand the full meaning of pictures, but they are greatly hampered by their jargon if they attempt to convey to others or silently to themselves what they have gathered They are able to draw, unless misled by defective verbalization and can often produce an accurate ground plan of some familiar room.

'This disorder is essentially one of balance and rhythm in symbolic expression and syntax suffers greatly The patient has plenty of words, but their production is ataxic, and they are strung together without the usual connecting links This leads to jargon and renders difficult even internal formulation of words and their meaning."

Nominal Defects —' This is essentially a loss of power to use names and want of comprehension of the nominal value or meaning of words and other symbols Not only does the patient fail to name objects placed in front of him but, when asked to point to one of them named aloud or in print, the choice even if correct, is made slowly and with effort.

There is no lack of words and if the patient is intelligent, he evokes one after another all more or less aptly associated with the name or expression he is trying to discover He frequently employs some descriptive statement, such as 'what you cut with *for scissors* or in the case of color may indicate how it is composed or the circumstances under which it is used Verbal structure may suffer during the struggle to find the right word but repetition is not materially affected provided they are presented in articulated form the sounds can be reproduced correctly The essential defect is inability to fit a name to an object or an object to a name to recognize the difference between words of contrasted significance and to execute promptly oral and printed commands. This disorder is mainly due to defective appre-

ciation of meaning and inability to evoke a desired name, both internal and external speech suffer as a secondary result.

"Such patients read with extreme difficulty both to themselves and aloud especially if they attempt to spell out the words. Single letters even if correctly enunciated frequently fail to convey their full nominal significance. Printed orders are badly executed but to read them aloud is a decided aid to their correct performance

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and 'time,' and knows that 'summer time' has something to do with the 'Daylight Saving Act,' he is unable to say if the clocks are put forward or back when it begins He can carry out a maneuver where each action suggests the next, but fails to do so if he is compelled to formulate it to himself as a whole and is unable to bear in mind with certainty the final goal towards which his efforts are directed.

'He has no difficulty in forming words and can repeat what is said to him But in general conversation his sentences tend to trail away aimlessly, as if he had forgotten what he intended to say If he is told some simple story and is asked to reproduce it by word of mouth or in writing many essential elements may be omitted this occurs to an even greater degree after reading it to himself silently He cannot retain the total conception of its meaning which is necessary for perfect narration. He may be able to enumerate the details one by one correctly, provided he is allowed to mention them in any order as they may happen to recur in his memory but his knowledge is episodic and is not co-ordinated by a general logically expressed formula.

"The clock tests reveal the nature of this disorder in a striking manner The patient confuses the two hands, does not know how to approach the task of setting them to oral or printed commands, and forgets the meaning of 'past' and 'to the hour Even direct imitation on one clock of the time shown on another may lead to confusion, for, whatever the form assumed by the test the patient is liable to misunderstand the intention of what he is asked to do On the other hand except in the gravest cases he has no difficulty in telling the time provided he is allowed to keep the clock in sight until he has given his answer

'Such patients can write but the result tends to be inaccurate and confused Although spelling may be careless and the letters imperfectly formed semantic defects are more liable to disturb the intellectual content and logical sequence of what is written than its verbal form. Not infrequently the written account of a set of ideas arising spontaneously or suggested by something the patient has heard or read trails away aimlessly just like the spoken narration of the same object. The power of reproducing a logical and orderly sequence suffers more severely than the direct act of writing.

'Counting is possible and the actual value of numbers and coins may be recognized correctly But the patient becomes confused if he is asked to state the relative value of two pieces of money In daily life he finds profound difficulty in calculating the price of an article he has purchased although he remembers how much he has expended. Arithmetical operations such as addition and subtraction are carried out uncertainly and with difficulty because the nature of such mathematical processes is incomprehensible

Such patients fail to understand jokes which demand complete comprehension of printed words or pictures. They cannot play card games draughts or dominoes nor can they put together puzzles which confuse them greatly

"Drawing even from a model, shows considerable loss of general constructive power These patients do not, as a rule block out the drawing but tend to begin at some one point and follow round the outline of the object detail by detail this weakness of design is also evident when they try to reproduce it from memory Attempts to draw an elephant usually end in confusion and occasionally the marks on the paper do not correspond to a coherent figure of any kind

'None of this group could draw a plan spontaneously of a room with which he was familiar unimportant details might be filled in, though salient features such as the windows and doors were omitted This is not due to lack of memory of details but to want of power to unite them into a coherent whole For if I drew an outline plan and indicated upon it the position of each object as the patient pointed it out to me, he could subsequently reproduce this plan without fail

These patients are completely unable to find their way alone they do not take their bearings and fail to recognize landmarks or to appreciate that they are passing over ground that should be familiar They do not know which way to turn and if they chance to cross to the opposite side of the road become confused ignorant in which direction to walk.

"Semantic disorders interfere seriously with the activities of daily life The patient finds difficulty in collecting the subjects required to set the table for a meal in adjusting the complexities of a military belt, or in putting together the different parts of a piece of furniture he has constructed. Such defects render him useless for any but the simplest employment yet his memory and intelligence may remain on a relatively high plane He does not forget people and places and his power of remembering detail is sometimes remarkable He can recall spontaneously events both recent and remote and may be able to furnish valuable information with regard to his disabilities It is not 'memory' that is affected but the power to co-ordinate details into a general formula for external statement.

"The tendency to confusion and want of comprehension of what is going on around them leads these patients to seek solitude and to shun their fellows. In some instances this produces an odd form of behavior or even a definite psychosis

The full direct quotation from Head s description of these disorders of speech has been given purposefully It would be needless repetition to call attention to possible methods of re-educating these patients after they have been so clearly pointed out by Head It should be emphasized that they are simple and can be carried out daily by the interested and intelligent co-operation of relatives

TREATMENT OF LESIONS RESULTING IN SENSORY DISABILITY

Vascular lesions of the cerebrum which involve the posterior limb of the internal capsule are characterized by a spastic hemiplegia which is accompanied by a hemianesthesia upon the same side as the motor dysfunction Intracranial tumors which involve the parietal lobe that

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atonia are the most outstanding symptoms of cerebellar disease Voluntary movements may be performed with excellent motor power but with marked incoordination and loss of the ability to measure accurately the range of movement. In general lesions of the cerebellar hemisphere give rise to symptoms in the extremities while the vermis of the cerebellum exercises a control over the trunk movements However not too much dependence must be placed in the exact localizing value of clinical signs for very frequently a lesion quite discretely placed within one hemisphere may by its symptoms lead one to diagnose a midline tumor and vice versa

The affected limbs show a definite decrease of muscle tone and are flaccid and rather flaillike The hand and fingers or the foot may be dorsiflexed or plantar flexed to an abnormal degree If the forearm is held fixed at the elbow it may be shaken so that the hand flaps about like a loose appendage If the forearm is flexed strongly against resistance *which is removed suddenly the hand may be jerked toward the* patient s shoulder with a grossly uncontrolled movement. This loss of check reflexes may be demonstrated in the upper and lower extremities in a variety of ways If for example the knee reflex is obtained with the patient sitting and the lower leg dependent the initial jerk is followed by many repeated oscillations before the leg finally comes to rest. *Attempts to perform rapidly alternating movements* with the hands are characterized by large awkward incoordinated movements upon the affected side

Likewise the tests for dysmetria or asynergia are characteristic of cerebellar dysfunction. If the patient attempts to place his forefinger on the tip of his nose with his eyes closed the affected extremity misses the mark widely or there is a coarse ataxic tremor present at the end of the movement. The same loss of the ability to measure a movement may be shown by the test which requires the patient to place the heel of one foot upon the opposite knee with the eyes closed.

The atonia and asynergia are exhibited in the drunken swaying gait of the patients with cerebellar disease The ability to balance themselves may be markedly affected This may be tested by having the patient stand on one foot alone and unsupported With the affected extremity raised he will be totally unable to balance himself and the affected extremity will describe large awkward arcs as he attempts to maintain his equilibrium On the contrary when he stands on the affected extremity with the sound one raised he is able to balance himself much better

In lesions which affect the vermis of the cerebellum the patient may be wholly unable to sit erect unsupported The entire upper body may pitch forward, backward and laterally in the attempt to remain upright.

Attention has been called to these signs and symptoms of cerebellar dysfunction because they point out quite simply and effectively the methods to be used in re-education. It must be emphasized that there

is, posterior to the central sulcus produce sensory disturbances. This is also true of traumatic lesions which involve the same portions of the cerebral cortex

All of these sensory changes differ considerably from those which accompany spinal cord or peripheral nerve lesions Usually there is no gross loss of sensation in the sense of an absolute analgesia or anesthesia. There may be slight, if any, change in the patient's ability to appreciate tactile painful or thermal stimuli Rather, he may describe them as unnatural and be unable to localize accurately the site of the stimulus

On the contrary, such a patient is unable to appreciate the sense of position or small movements of a segment of the limb We have recently observed two patients with verified gliomas situated deep within the parietal lobes, and both complained of an inability to place themselves accurately in space. No doubt a part of this feeling of dissociation from spatial limits was due to an existing homonymous hemianopsia. The patient may be unable to recognize the size, shape, weight or consistency of objects.

If the lesion involves the optic thalamus, the threshold for the reception of painful and thermal stimuli may be lowered greatly The response is greatly exaggerated so much so that acute pain and suffering may result from insignificant stimuli. This type of paroxysmal or thalamic pain may resist all forms of active treatment.

While trophic ulcerations of the skin characteristic of peripheral nerve lesions are not present in cerebral lesions, the impaired circulation of the skin predisposes to decubitus lesions. Cleanliness, dryness, and the use of ultraviolet light on the skin are excellent prophylactic measures which may be employed when a patient is confined to his bed for a considerable period of time.

The re-education of sensory function may be undertaken upon the same fundamental principles already outlined for the treatment of motor disability The patient may be taught to pick out various-sized coins or other objects upon command with his eyes closed. He may practice touching various parts of his body with the forefinger with his eyes closed. In a similar manner he may re-educate his sense of the appreciation of the shape of square triangular, or rectangular wooden blocks Various textures of pieces of cloth may be used for re-educational purposes. Here again all of these simple exercises may be multiplied many times and all of them may be carried out daily in the patient s home

Cerebellar Lesions

The most common causes of cerebellar dysfunction are intracranial tumors in the posterior cranial fossa and traumatic lesions which produce direct injury of the cerebellum. Whereas cerebral lesions produce symptoms on the contralateral side of the body cerebellar lesions are characterized by ipsilateral signs and symptoms Asynergia and

atonia are the most outstanding symptoms of cerebellar disease. Voluntary movements may be performed with excellent motor power but with marked incoordination and loss of the ability to measure accurately the range of movement. In general lesions of the cerebellar hemisphere give rise to symptoms in the extremities while the vermis of the cerebellum exercises a control over the trunk movements However not too much dependence must be placed in the exact localizing value of clinical signs for very frequently a lesion quite discretely placed within one hemisphere may by its symptoms lead one to diagnose a midline tumor and vice versa

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Attention has been called to these signs and symptoms of cerebellar dysfunction because they point out quite simply and effectively the methods to be used in re-education. It must be emphasized that there

is no paralysis present. Active voluntary movements are possible, but they are asynergic. We have been impressed with the striking results which have been obtained in our attempts to re-educate patients who have been operated upon for the removal of intracerebellar or cerebellopontile angle tumors Simple exercises designed to re-educate coordination of their muscles and based entirely upon the characteristic signs of their dysfunction have been employed It is quite true that in some instances former occupations which require finely controlled and coordinated movements cannot be regained but gainful occupations which require less accurate movements may be opened to these patients

We have employed such simple exercises as having the patient pick up a glass of water from the table, take it to the mouth and replace it without spilling its contents He must be shown how to do this in one continuous, smoothly coordinated act. He may be taught to practice walking along a straight line drawn on the floor, making certain that he looks ahead and not down at his feet. Again, he may practice the same acts which have been described as tests for cerebellar dysfunction Here as in cerebral lesions results may be obtained more satisfactorily if purposeful exercises are employed to hold the patient's interest and to provide a goal toward which he may strive. Adult patients may be self-conscious in making their practice maneuvers before an audience and it is important that the patient practice his movements with relaxation, self-confidence and a feeling of steady attainment. Doubt or discouragement must not be allowed to develop in his mind We have also employed motion picture studies to show these patients the results of their persistent efforts.

Spinal Cord Lesions

The symptoms which result from involvement of the spinal cord are to be distinguished from those which result from injury or disease of the cauda equina. Spinal cord lesions are characterized by the symptoms of an upper motor neuron lesion These are spastic paralysis increased deep tendon reflexes pathologic reflexes absence of superficial reflexes and absence of muscle atrophy and of the reaction of degeneration. In direct contrast cauda equina lesions are essentially like peripheral nerve lesions in that the symptoms present are those of a lower motor neuron lesion These are flaccid paralysis muscle atrophy the reaction of degeneration and absence of deep tendon reflexes and of pathologic reflexes.

The motor dysfunction in either event is one which involves most commonly the lower extremities A spastic or flaccid paralysis is, therefore highly suggestive of spinal cord involvement. Lesions of the cervical segments of the cord may of course affect all four extremities and a quadriplegia results.

FIG. 3 —Marked flexor and adductor spasms and contractures which followed gunshot injury f the spinal cord. This patient had recei ed no physical therapy of any kind. While physical therapy is useful and necessary even t this stage of deformity it is obvious that recovery of function is less probable than it would have been had proper care been given early to this patient.

SPASTIC PARAPLEGIA

The paraplegic state is analogous to the hemiplegic state described previously as the result of cerebral lesions The gait of a spastic para plegic patient is quite characteristic. When the feet are on the floor they seem to be glued there The upper portion of the body is inclined forward as the patient attempts to advance The pelvis is elevated to one side while the corresponding extremity is dragged forward Clonic movements of the limb may interfere with placing the foot upon the

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from the slightest to the most extensive in the different types of cases A rupture of the intervertebral disk into the vertebral canal may in some cases with the lesion being of large size and lying in the cervical or thoracic canal, cause spasticity of a certain degree.

Degenerative Diseases of the Spinal Cord —The most common degenerative diseases which produce spastic paraplegia are lateral sclerosis amyotrophic lateral sclerosis posterolateral sclerosis which accompanies pernicious anemia syringomyelia multiple sclerosis and the familial ataxic disorders In all of these diseases the lateral pyramidal tracts undergo progressive degeneration The spasticity and paralysis develop gradually and insidiously

In lateral sclerosis the degeneration is limited to the pyramidal tracts and sensory disturbances are absent. Only the lower extremities are involved so that the clinical picture is one of a pure spastic paraplegia. In amyotrophic lateral sclerosis there is a concomitant lesion of the spinal gray matter of the cervical segments of the spinal cord. In this disease therefore there are the combined symptoms of a lower motor neuron lesion in the arms and an upper motor neuron lesion in the legs. The upper extremities present atrophy loss of tendon reflexes and flaccid paralysis plus the reaction of degeneration At the same time the lower extremities present the symptoms of a spastic paraplegia in varying degrees Sensory symptoms are absent.

Pernicious anemia is the one disease which attacks the lateral pyramidal tracts and the fibers of the posterior columns of the cord simultaneously The predominance of the paraplegic state over that produced by the posterior column disease similar to that present in tabes dorsalis or vice versa is dependent upon the extent of the pathologic processes Subjective and objective sensory disturbances vary greatly in each case Syringomyelia may produce a clinical picture similar to that seen in amyotrophic lateral sclerosis In addition however there are marked sensory disturbances due to the involvement of the pain and temperature fibers as they cross in the anterior gray commissure Multiple sclerosis is characterized by the scattered nature of the pathologic lesions present in the cord and medulla. Sensory disturbances may be present but are usually not well marked The upper extremities are less frequently involved in the general loss of power In both upper and lower extremities the weakness or paralysis is associated with a comparatively moderate degree of spasticity

A group of cases has been described by a number of authors beginning with Strümpell, which presents pure spasticity and familial traits The spastic condition may appear at any age and there is paresis only in the terminal stages of the disease Increased tendon reflexes and hypertonicity of the muscles are the outstanding symptoms Sensory and sphincteric difficulties are absent The rigidity of the legs may be so marked as to make the gait spastic and walking impossible

Trauma —Injury of the spinal cord may be the result of direct trauma to the cord as by a gunshot wound a splinter of bone con

floor, so that the heel is elevated and the patient moves up and down on his toes Finally, the limb becomes fixed, and the opposite extremity is advanced in the same manner Frequently these short and jerky steps may be interrupted by violent overaction of the adductor muscles of the thighs which displace the knees inward Sometimes a cross-legged or scissors gait is produced

If walking is impossible, the same cross-legged attitude is characteristic of the patient as he stands. The tendency is for the knees to adduct and for flexion of the knee and hip joints to occur The patient may flex his trunk far forward at his hips in his efforts to remain standing and to prevent these adductor and flexor spasms from causing him to fall

When the patient is bedridden and a spastic paraplegia is strongly developed the lower extremities may be extended rigidly The adductor muscles of the thighs are strongly contracted and may cause the limbs to be crossed The marked rigidity may cause the extremities to act like rigid pipes which are hinged together Passive movement of one foot upward may be followed by a like movement in the other extremity because of this rigidity In other severe cases of paraplegia, rigidity may occur in flexion The legs are strongly flexed on the thighs and the thighs, in turn, may be so completely flexed on the trunk that the knees touch the patient s sternum. Commonly in such cases there is also a strong adductor spasm which makes these patients appear to be tied into a knot. It has been our observation that these flexor reflex movements are initiated by the adductor spasm which is, in turn followed by flexion of the limbs (Fig. 3)

The deep tendon reflexes may be exaggerated incredibly in these patients The slightest touch may cause violent reflex movements which throw the patient about on his bed or produce flexor withdrawal reflexes which result in a posture similar to that presented by the patient with a paraplegia in flexion

The bladder and bowels are affected to a variable degree in these cases. Lesions of the lumbar cord destroy the vesical and rectal reflexes, while involvement of the cord at higher segments removes the patient's control over these functions. Quite frequently patients may develop an automatic bladder which empties when its contents have reached a given amount. Mass reflexes may also be present in which the entire limb flexes upon stimulation this is accompanied by expulsion of the contents of the bladder

Sensory and trophic disturbances are variable depending entirely upon the horizontal involvement of the spinal cord substance. Contractures may produce deforming postures which seriously cripple these patients and make operative measures necessary to afford them relief from their suffering.

Etiology —The most common causes of a spastic paraplegia are (1) degenerative diseases of the spinal cord (2) trauma (3) tumors, (4) birth injuries, and (5) infectious diseases. The symptoms vary

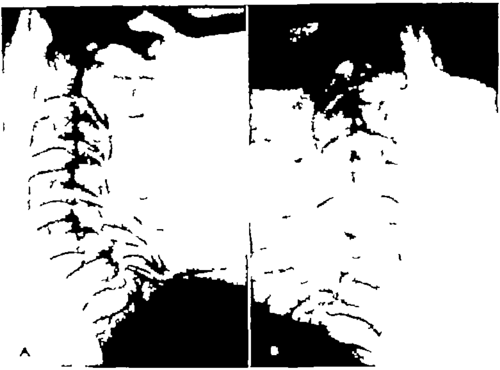

FIG. 4—A Dislocation of the fifth upon the sixth cervical vertebra, together with comminution of the body of the seventh, producing an incomplete lesion of the spinal cord. (Before application of traction.)
B The same patient, with the dislocation completely corrected Twenty four hours after the accident, when the patient was first seen, skull t ngs were put in place and 20 pounds of traction applied. He was immediately relieved of neck and shoulder pain and soon showed signs of neurologic recovery Note the increase in length of the total cervical spine after reduction. (Photograph taken three days after application of traction, with traction still in place.)

is more commonly observed whereas in incomplete lesions frequently extensor types of movements are present. In complete lesions the posture of the lower limbs is one of slight flexion in partial lesions extension. As a general rule, partial lesions of the spinal cord generally show a condition comparable to that of a decerebrate animal in which there are defense reflexes with marked spasticity Although an extensor type of response to plantar stimulation has been observed in complete section of the spinal cord usually such a stimulation is followed by a plantar flexion of the toes and as a fairly general rule it may be stated that an extensor type of reflex is strongly indicative of an in complete lesion. Inasmuch as prolonged states of toxemia or septicemia from urinary sepsis or bed sores hasten considerably the reappearance of reflex inactivity in cases of complete section of the spinal cord it frequently occurs that from the practical standpoint, incomplete lesions are relatively easily recognized by the long persistence of spasticity and signs of a paraplegia in extension Of particular value in recognizing incomplete lesions is the early appearance of a Babinski sign the failure to evoke mass reflexes from above the knee a definite

cussion or contusion, or it may be the result of indirect trauma, as compression from a fracture-dislocation of a vertebra, or edema. Although hemorrhages and thrombi may abound at the level of the injury and to a distance of one or two segments above and below, a true hematomyelia is a rare occurrence.

Frequently severe injury and, at times, incomplete section of the spinal cord, have been observed with an intact dura mater As in the case of peripheral nerve lesions, a complete physiologic interruption of the spinal cord cannot be differentiated from a complete anatomic one. Both are followed by complete paralysis in the muscles supplied by nerves originating below the level of the injury In both complete sensory loss results below the level of the segment, and the reflex changes and bladder disturbances may be similar Although many cases of incomplete anatomic lesions of the spinal cord show complete physiologic interruption, a large number may be recognized by only partial paralysis of the muscles below the level of the lesion or by preservation of one or all types of sensibility Prior to the Great War Bastian s law—that, following a complete transection of the cord flaccidity was present and all reflex action was lost—was almost universally accepted and seemed to afford a method for the easy recognition of this condition Recent observations, however varying, have shown definitely that this law is untenable.

Symptomatology.—The symptomatology following a complete transection of the spinal cord may be divided into three stages First is the stage of muscular flaccidity, corresponding to the period of spinal shock in which the paralyzed muscles are toneless and flabby and all reflexes superficial and deep are usually absent with retention of urine and feces At times retention of urine and incontinence of feces have been observed and at times the cremasteric and bulbocavernosus reflexes have been elicited The second stage the stage of reflex activity begins with the first reflex response to an external stimulus usually from the sole of the foot In the full development of this stage a stimulus applied to any part of the lower extremity gives rise to a flexion reflex of the hip with adduction of the thigh knee and ankle. When reflexes can be evoked with ease an extensive and widespread reflex action can be obtained which has been called a "mass reflex." This consists of a flexion spasm of the ventral abdominal wall and of the lower extremity evacuation of the bladder when its contents accrue to a certain amount, and sweating from an area of the skin in the paralyzed region One of the most receptive fields for exciting reflexes is the genital area. During this stage in some cases the knee and ankle jerks can be evoked. Under favorable conditions an automatic function of the bladder and rectum may be established usually in the third week. The third stage that of gradual failure of reflex functions of the isolated spinal cord usually preceding death consists of a gradual return to a condition closely simulating the first stage.

Certain differences of reaction in complete and incomplete lesions may be pointed out. In complete lesions the flexor type of movement

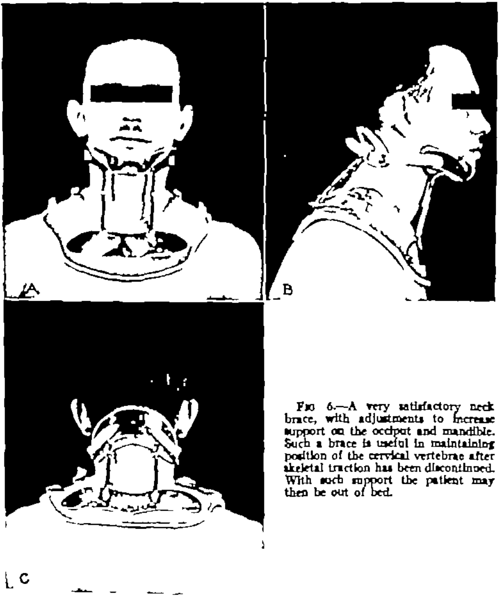

Fig 6.—A very satisfactory neck brace, with adjustments to increase support on the occiput and mandible. Such a brace is useful in maintaining position of the cervical vertebrae after skeletal traction has been discontinued. With such support the patient may then be out of bed.

The spastic paraplegia is usually of gradual development in compression of the cord due to tumor masses although occasionally one may see the sudden onset of paraplegia due to erosion and collapse of a vertebra by a tumor mass or as the result of a sudden dislocation of a tumor within the vertebral canal We have also seen this happen in young patients who suffered a spread downward in the cerebrospinal axis of a rapidly growing medulloblastoma in the posterior cranial fossa. Root pains which surround the trunk or radiate into the limbs may be early symptoms Complaints of heaviness weakness and clumsiness of the legs may be made long in advance of paralytic symptoms Tingling or "electric" pains are frequently complained of and each

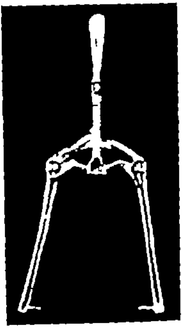

FIG. 5.—Skull tongs which are placed in the outer table of the skull at the superior temporal line above the ear The swivel handle allows free motion for the application of traction weights (18 to 20 lbs.) and for moving the patient. Such skeletal traction should be applied as soon after a cervical fracture-dislocation as possible, and it should be maintained continuously for 25 to 30 days.

history of an absence of a state of spinal shock, marked tonicity in the paralyzed extremities, the involvement of both flexors and extensors in reflex movements provoked by the stimulation of receptive fields, and of course, in obviously incomplete lesions, the absence of total paralysis or anesthesia below the level of the lesion.

Fracture-dislocations of the cervical vertebrae, with cord damage, present a somewhat specialized problem in the traumatic group The injury is frequently at the level of the fifth and sixth vertebrae, with a resultant paralysis of all the muscles of respiration save the diaphragm. If the lesion is a physiologic one and it frequently is, the entire symptomatology may change within a day or two after mechanical correction of the deformity We have used skull tongs with good success in such cases and if adequate weight is used for traction there is a rapid return to normal bony alignment in the fresh injuries, with an immediate relief of shoulder and neck pain and the appearance of signs of neurologic recovery (Figs 4–6)

TUMORS.—Spinal cord tumors may be intramedullary or extramedullary in location The extramedullary tumors may be intradural or extradural and may produce compression of the spinal cord at any point about its circumference Intramedullary tumors of the cord may simulate any of the degenerative diseases of the spinal cord in their symptomatology Extramedullary tumor masses may arise from the meninges of the cord or from the vertebrae.

motor neuron lesion. The deep tendon reflexes are absent, there is muscle atrophy the reaction of degeneration is present, and sensory changes form a prominent part of the clinical picture. The cauda equina of the spinal cord is involved in the pathology of these lesions Their resemblance to peripheral nerve lesions is striking.

The most common etiologic factors which produce a flaccid paraplegia are fracture-dislocation of the lumbar vertebrae and tumors of the cauda equina. Here must be included also the ruptured intervertebral disk which is so commonly found between the third and fourth lumbar vertebrae or between the fourth and fifth. Anterior poliomyelitis which produces the syndrome of a lower motor neuron lesion should also be included in the etiology of flaccid paralysis of the lower extremities. In this disease there is a total absence of sensory disturbances The varying degrees of paralysis which may result from this disease and the late treatment of this condition are considered in Chapter 8 and therefore will not be considered here

TREATMENT OF SPASTIC AND FLACCID PARAPLEGIA

The treatment of spastic and flaccid paraplegias as the result of spinal cord and cauda equina lesions by the use of physical therapeutic means may be considered together The differences in the treatment of the spastic and flaccid paraplegic states may be emphasized as each type of therapy is discussed The results of physical therapy in the treatment of flaccid paraplegia are much more satisfactory than those which can be obtained in spastic paralysis

Massage.—Just as in the spastic limbs of the hemiplegic patient, so in spastic paraplegia, reflex activities are heightened. The slightest touch may produce marked adductor and flexor spasms Consequently massage in these cases must be very gentle and should consist of stroking rather than rubbing movements On the contrary massage may be more active and may be more effective in cases of flaccid paralysis Massage may be begun with a period of rhythmic superficial stroking Following this all of the muscles of the extremity should be massaged with a centripetal motion to affect the venous and lymphatic circulation More pressure may be used than at the beginning of the massage but care should be taken not to injure the paralyzed muscles by compressing them against bones This may be increased gradually until the massage consists of a gentle kneading

Massage should be preceded by exposing the extremities to heat for twenty to thirty minutes This is particularly useful in flaccid extremities. Radiant heat the infra red light hot packs or a whirlpool bath of warm water are all useful but they should be used with extreme care because of the ease with which the skin of a denervated area can be burned. The whirlpool bath if it can be used without too much difficulty is preferable because the motion of the water acts as a gentle massage.

patient will describe his paresthetic sensations in his own particular terminology As pressure upon the cord increases, compression of the pyramidal tracts occurs and spastic paralysis and increased tendon reflexes appear Spasticity, marked reflex movements, and muscular rigidity with contractures may become very pronounced in these types of slow cord compression. Sphincteric loss is a late feature of these cases and is usually preceded by lesser degrees of incontinence. Sensory disturbances vary in direct relation to the degree of involvement of the afferent fiber tracts in the cord. Trophic disturbances of the skin are quick to develop in the presence of poor nursing care and prolonged periods of confinement in bed, and it is to the interest of everyone concerned that such lesions do not develop in these patients who are always a great nursing care and whose eventual outlook may be precarious enough because of their spinal cord lesion alone.

Birth Injuries —A very important cause of motor disability in children is caused by injury to the spinal cord as the result of obstetric accidents In the opinion of Crothers [4] the majority of cases are due to the 'imposition of the unphysiologic force of traction." Crothers emphasizes the fact that the management of these children depends upon the intactness and re-education of the physiologic residue rather than upon the exact nature of the anatomic lesion If the lesion is confined to the spinal cord, the child at least has the advantage of a proper mentality The most common deformity presented is paraplegia, but the clinical picture may vary enormously with the degrees of partial injury which may be present. The least favorable cases are of course, those with physiologic or anatomic destruction of the lumbar enlargement of the cord Urinary sepsis and trophic ulcers complicate the care of these patients. Complete flaccid paraplegia may be present in some cases due to an almost complete destruction of the lumbar spinal cord

Infectious Diseases —A large number of spinal cord lesions have been grouped under the term "myelitis." Inflammation of the cord substance is probably never primary Infection may reach the cord by the vascular supply and not infrequently follows the exanthematous and septicemic diseases

Acute cases produce the maximum damage in a few days others require weeks If death does not result, gradual improvement may occur Decubitus lesions are serious complications in these cases. When spasticity develops there is rarely any recession and the paraplegic state which has been described results Localized muscle atrophy due to involvement of the anterior gray matter never improves.

FLACCID PARAPLEGIA

In direct contrast to the spastic paraplegic state is a paralysis of the lower extremities which is completely flaccid As was stated previously such a flaccid paraplegia presents the symptoms of a lower

neuron is uninjured, the trophic nerve supply to the muscles is intact and the intelligent employment of massage and active and passive movements will accomplish more with far less danger of harmful results.

On the contrary in the flaccid paraplegias electrotherapy may be used to great advantage Electrotherapy is indicated to prevent the atrophy of muscles and fibrosis to increase nutrition and to conserve the functional capacity of paralyzed muscles until sufficient return of function has taken place to permit of active motion.

Since the days of Duchenne neurologists have agreed that electrotherapy is of service in hastening the return of function in muscles paralyzed as the result of lesions of the lower motor neuron Although some physiologists have felt that it was useless others have shown by experimental studies that there is a sound basis for the belief that electrotherapy is of distinct benefit. Recently it has been shown particularly in peripheral nerve lesions that a more advanced type of regeneration of the nerve occurs when the denervated extremity is treated by electrotherapy

It is necessary to understand clearly the method of action of treatment by electricity Stimulation by an electric current of sufficient strength produces a contraction of the muscle It is this active contraction which conserves the volume and nutrition and keeps the muscle fibers in a functional state adequate for voluntary movement when regeneration occurs The only requirement of electrotherapy is that it produces a contraction of the paralyzed muscle This cannot be produced by the faradic current because the duration of each stimulus is too short in relation to the changed chronaxia of the nerve and muscle Galvanic current must be used therefore It may be used in its simplest form of a continuous current with a make and break key, or in the form of sinusoidal currents of various wave types

It has been said that a continuous current which produces a sharp contraction at the make or break is of little value because it does not resemble the normal contraction of a muscle On the other hand it is said that the sinusoidal current produces a slow contraction which is more nearly normal Physiologic experiments have never shown that muscles contract slowly in their normal state It may be accepted that the muscle contractions which result from the interrupted galvanic current stimulation are as useful as any other type of galvanic current.

The rapidity of the muscle contractions can produce no harm after the second week following injury or surgical procedures During the first two weeks the muscles should be kept at rest. After this period sudden contractions are as useful as slow ones The force of the contraction may be modified by the strength of the current Interrupted galvanic current is often painful and therefore other types of waves are useful in children or sensitive patients Since the muscle contraction occurs only upon making and breaking the current, prolonged stimulation is unnecessary The current should be applied with short makes and immediate breaks by the use of a suitable electrode

Active and Passive Movements.—Here, again, spasticity may interfere seriously with attempts to use active and passive movements in the treatment of a spastic paraplegia. Often when the patient attempts to perform an active movement the spasticity of the extremity becomes so marked that the limb becomes rigid, stiff, and immovable. This is particularly true if the patient is not relaxed completely or if he feels that the movement must be performed upon command. Consequently active movements in spastic patients must be begun slowly and very gradually, and unusual patience on the part of the patient and the nurse is imperative.

This is not true of flaccid paralysis. Active movements must be attempted and may be pushed as rapidly as the patient's progress permits. It is wise to aid the patient if necessary, so that the complete range of the particular movement is performed. Movements which occur reflexly in spastic paralysis must be differentiated from true voluntary movements and must not be interpreted as evidence of return of motion.

Passive movements may be employed to greater advantage than active movements in spastic extremities. They must be used carefully and gently, however, so that large defensive reflex movements may not be excited. As Langley[5] has pointed out, intermittent passive or active stretching forces lymph, and so presumably metabolic products, from the muscles. Moreover, such active or passive movements have a distinct influence upon the formation of connective tissue, the formation beginning rather quickly in lower motor neuron lesions. Part of the late contractures in flaccid paralysis may be due to the shrinkage of this newly formed tissue which is soft and extensible. Active or passive movements will stretch the developing connective tissue fibers so that, when they do shrink, there may be less tendency to a contracture.

Passive movements may be carried out very well in conjunction with massage. They help to stretch contractures which have already occurred and to prevent those which invariably occur in an inactive or denervated muscle. They also increase the range of motion in an already stiffened joint and help to keep a mobile joint active so that, when the time comes, it is ready to perform its part as an effective mechanism. Finally, such movements help to re-educate the muscles in performing normal movements. Each separate passive exercise should be individualized and the patient should be required to make the attempt to perform the movement simultaneously or to attempt to hold the part in the position imposed upon it.

Electrotherapy.—The use of electrotherapy in spastic paraplegic patients accomplishes very little as compared to the results which may be obtained in the flaccid paralysis. As a matter of fact, the heightened reflex activities of the spastic extremities may offer strong contraindications to its use. In upper motor neuron lesions, muscle atrophy does not occur except as the result of nonuse. Since the lower motor

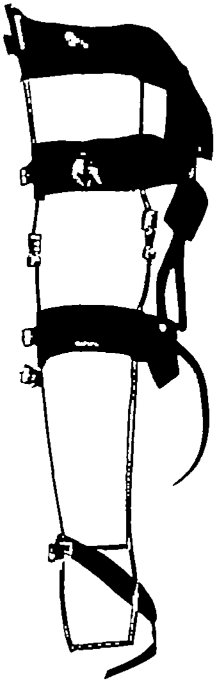

FIG. 8 —Thomas type of caliper splint which may be modified as desired for a paralysis of the lower extremity

Contractions of muscles produced by electric current are a valuable aid to re-education and active motion Although the patient may not be able to produce dorsiflexion voluntarily the ankle may be held in that position after electrical stimulation has produced dorsiflexion

FIG 7.—A simple spring splint to aid in dorsiflexion of the foot and to prevent footdrop

During the first few months following the paralysis, the muscles are hyperirritable Unipolar stimulation will produce contractions in the muscles most affected by the weakest currents, because of longitudinal stimulation Consequently fatigue in these muscles must be avoided Deep muscle sense may be defective and the patient is unable to tell when his muscles are fatigued

Later the most affected muscles become less irritable and unipolar stimulation produces a spread of current to unparalyzed muscles which alone may contract to the injury of the patient. Therefore, bipolar electrodes should be used at this stage Although polar inversion does not always take place in degenerated muscles, it occurs in such a large number of cases that the positive pole should be used as the active electrode It is also the least painful

In producing contractions of the paralyzed muscles care must be used to prevent the force of gravity from acting against the contracting muscles This factor may hide movements of segments about the joints and may increase the onset of fatigue. The extensors of the foot may not produce a movement with the extremity in a position of foot drop but if the patient rests the leg on a board at the outer surface dorsiflexion may occur

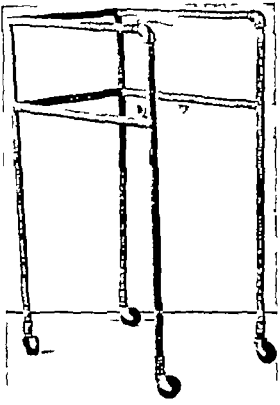

FIG. 10.—A simple type of walker made of ordinary gas pipe and large ball-bearing casters, very useful in the first walking attempts of a paraplegic patient.

so that it may prove more desirable to use light crinoline posterior molded splints which may be removed easily for massage and passive movements There is no reason for using heavy plaster-of Paris boots which are out of all proportion to the effect desired Adhesive tape straps from the sole of the foot to the dorsum of the leg may also be effective.

When the patient becomes ambulatory the most satisfactory splint to prevent footdrop is one patterned after that shown in Figure 7 This is a simple device and can be attached to the shoe easily As is usually the case the remainder of the extremity also requires support. A modification of the Thomas caliper splint may be employed (Fig. 8) A spring lock at the knee joint enables the patient to flex the knee when he sits When he is standing or walking this lock closes and the knee is kept in extension. The additional footdrop splint may be attached very simply to this type of apparatus Figure 9 illustrates another variety of splint which may be used when the residual paralysis affects the lower leg predominantly

Exercise and Muscle Re-education.—Very often the paraplegic patient is looked upon by his physician with the same air of hopeless-

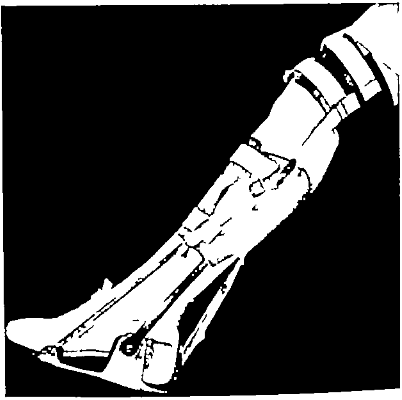

FIG. 9—A splint for use in paralysis of the lower leg combined with a footdrop. The principle of such a splint is easily varied to suit individual needs.

Care must be exercised in treating areas of skin in which sensation has been destroyed Burns are produced easily, and when ulceration once occurs healing is difficult.

When the nerves and muscles have recovered sufficiently to contract to faradic stimuli both galvanic and faradic stimulation are advisable the purpose of the latter being to produce more prolonged or tetanic contractions.

Splints.—We have found splints of little or no use in the treatment of spastic paralysis of the lower extremities once it is developed. Deformities and contractures may in part be prevented from developing by massage and passive movements of the joints When the patient is confined to bed the extremities should be kept in extension and in abduction by the use of sandbags and pillows. The feet may best be held up in a functional position in order to overcome a forward drop of the feet, by a foot board which can be moved up and down the frame of the bed to accommodate to the position of the patient in bed.

On the contrary much can be done by the intelligent use of splints in cases of flaccid paraplegia While the patient is in bed footdrop may be avoided by the use of sandbags against the soles of the patient s feet and a cradle over the legs to keep the weight of the bed clothes off the feet. These require careful and constant adjustments,

FIG. 12—A walking frame combined with mirrors is a useful agent in re-educating a patient t walk.

floor of this aisle consists of a board upon which are painted square spaces which are numbered These vary in size The patient attempts to place his feet within these spaces and as his skill develops the wider spaces are utilized. The results of this method may be increased by having the patient observe the movements of his legs in a mirror (Figs 11 12)

We have also found that the movements of the lower extremities may be more easily performed in slightly warm water This is true of the cases of spastic as well as flaccid paralysis A Hubbard tank (Fig 13) is an excellent means of carrying out these underwater movements Since the tank may be installed in the basement of the patient s home and is relatively inexpensive it is extremely valuable.

These few examples of methods of re-education of the muscles of the lower extremities may be multiplied many times In more ad vanced cases a stationary bicycle may be used or a rowing machine may be employed to advantage Just as in the re-education of the upper extremities productive educative exercises for the lower extremi ties intrigue the patient and secure his whole hearted co-operation

FRÄNKEL EXERCISES.—Though not strictly a spinal cord disease tabes dorsalis produces ataxia in the lower extremities which may be

FIG. 11—A patient engaged in walking exercises, stepping on markers designed for graduated active exercise.

ness as is the hemiplegic one. Many times massage, active and passive movements electrotherapy and splinting are carried out quite effectively until the patient is ambulatory and then his further treatment is neglected.

It is necessary to teach the recovering patient to use his recovering muscles to his best advantage He must be taught to walk again While one may feel that this will be accomplished gradually in spite of what may be done our cases have progressed more rapidly as the result of directed muscle exercises and re-education

One of the simplest devices to teach the patient to use his extremities may be made of small iron pipes and is similar to a baby's walker The patient stands within this frame which is on rollers and rests his weight upon his arms grasping the sides with his hands (Fig. 10)

Another excellent method of re-education in walking is to have the patient walk in an aisle bounded by iron pipes which may be grasped easily and upon which he may rest his weight as he progresses. The

4 In the standing position the patient should place one foot in front of the other With his hands across the chest he should flex his knees and then slowly raise himself

5 The second exercise may be repeated and extended so that the patient places one foot behind the other This requires and educates the sense of balance

6 With the feet together the patient should stand alone with his hands on his hips

7 With the feet separated in a normal position of standing and without a cane, the patient should perform various acts with the hands and arms

These exercises may be lengthened and enlarged as the patient develops his coordination and of course are as valuable in cases of flaccid paraplegia of spinal cord origin as they are for patients with tabes dorsalis

Surgery —Marked deforming contractures may follow neglected cases of spinal cord involvement. Attention has been called to the flexor and adductor contractures in spastic paraplegia. Division of tendons peripheral nerve section such as severance of the obturator nerves in adductor spasm and extensive posterior spinal root sections must be considered as a part of the treatment of these cases Often a bedridden patient may be made ambulatory by posterior root section After such a procedure the patient must be trained thoroughly and persistently by re-educational exercises and other physical therapeutic methods

Modification of Treatment Because of Sensory Disturbances.—The loss of sensation is variable as a result of spinal cord lesions Cauda equina involvement is characterized commonly by sensory loss about the buttocks This has given rise to the term "saddle anesthesia.

Because of the sensory disturbances present extreme care must be taken to avoid decubitus lesions of the skin of the back and buttocks The skin must be kept scrupulously clean and dry Alcohol rubs and the application of cocoa butter should be used freely If possible the patient should be turned on the side and propped there by pillows so that strain on the paravertebral muscles is avoided This distributes the pressure of the body over various areas of skin and allows the back to be treated efficiently

Harsh stiff linen sheets which burn the skin must be avoided The linen must be changed immediately if it becomes soiled from an incontinence of urine or feces

Decubitus lesions may be treated with excellent results by a few simple procedures at the patient s bedside Care should be taken to débride the ulcers of all necrotic tissue Undermining sloughing pockets of dead tissue should be searched for and removed After such débridement the wound may be gently cleansed with plain soap and water and irrigated with normal saline solution. It should then be dried

FIG. 13—Patient performing exercises under water in a Hubbard tank.

treated very successfully by a system of re-educative exercises just described There is a considerable amount of literature concerning the results of treatment of tabes dorsalis by Fränkel exercises.

Fränkel[4] has described two classes of exercises—those for bed-ridden and those for ambulatory patients In bed the patient is taught to flex, abduct adduct and extend each leg separately and both legs simultaneously The knees and hips are also exercised The patient should place the heel of one foot on the knee of the opposite leg and then pass it slowly down the tibia toward the ankle. These exercises should be carried out with the eyes opened and closed They may be repeated twice daily for as long a time as the patient's condition justifies

For ambulatory patients Fränkel has described the following valuable series of exercises

1 The patient is placed with his back to a chair and then, with his heels together is asked to lower himself slowly into the chair and to rise in the same manner Crutches or canes should not be used. It may however be necessary at first to provide the patient with the support of an attendant

2 One leg may be placed at the distance of an ordinary walking step in front of the other and then returned accurately to the original position The patient may support himself during this exercise, if necessary with a cane

3 The patient is asked to walk several steps slowly and with precision

A laminectomy was performed and the compression due to the bony fragments was removed For the last two years the patient has received massage active and passive movements, electrotherapy and re-educative exercises. He is now able to walk with the aid of crutches His ability to stand with the support of his crutch at the end of the two-year period is shown in Figure 13 Persistent daily re-educative exercises at home played a very important part in this man's rehabilitation and he was seen at frequent intervals after his discharge from the hospital in order that new exercises might be provided as his condition improved

H S., a 48-year-old housewife was injured in an automobile accident and suffered, among other injuries a fracture-dislocation of the fifth cervical vertebra. She immediately showed signs of a physiologic lesion of the spinal cord, with only a slight amount of motion in the arms and hands. The legs were completely paralyzed. For four months she had no treatment of any kind and no attempt was made to reduce the fracture while it was still fresh. The improvement in her condition during that period was essentially nil When she was first seen in this clinic it was discovered that she not only had an incomplete lesion of the cord but also a complete subarachnoidal block. The dislocation had existed for too long a time to make reduction possible therefore a laminectomy was performed Immediately her symptoms began to disappear She was started upon a course of systematic physical therapy including heat, massage active and passive exercises Her recovery was so rapid that she was discharged from the hospital fourteen days after the operation and in three weeks from the date of discharge she walked into the office for a check up visit. Physical therapy has been used continuously until the present, with special emphasis on re-educative active purposeful movements. Now less than one year after operation she walks alone without a cane or other support of any kind and she can use both hands accurately and normally except for a few fine movements.

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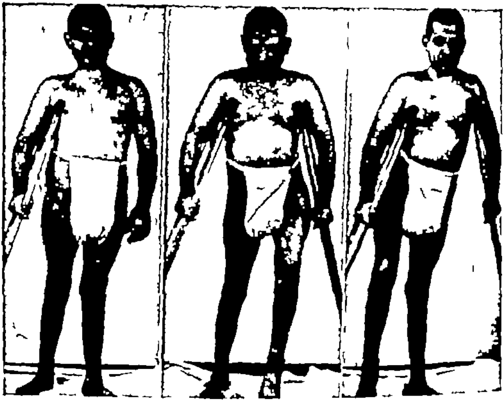

FIG. 14.—Flaccid paraplegia which resulted from a fracture-dislocation of the third lumbar vertebra The patient regained the use of his lower extremities following per sistent and intensive physical therapy

with a simple heat lamp and left exposed as long as possible to the open air Only aseptic surgical technic should be used in the treatment of such ulcers, and *daily* care is imperative. Frequent exposure to ultraviolet light has been of great aid in the rapid healing of such lesions in our patients

In many spinal cord disturbances, perforating ulcers of the large toe and heel occur These too must be kept clean and free from infec tion They are usually painless and begin as a callus or corn. Ulcera tion follows and if untreated the bone may become denuded. Dry heat and ultraviolet light exposures aid materially in keeping these lesions dry and clean

Report of Cases.—The results which may be obtained by the per sistent use of these therapeutic measures in spinal cord injuries may be illustated by a brief recital of the following cases

C D (Fig 14) aged 46 received a fracture-dislocation of the third lumbar vertebra in an automobile accident in 1929 There was an immediate flaccid paralysis of both lower extremities. There was incontinence of urine and feces and there was loss of sensation over the area supplied by the fifth lumbar and all the sacral segments of the cord. Six weeks elapsed after his injury before he was brought for surgical treatment.

CHAPTER SIXTEEN

PHYSICAL THERAPY IN BACK INJURIES

HARRY E MOCK M D

GENERAL BACK INJURIES

Backache is one of the oldest complaints of the human race. Failure of our profession to solve more thoroughly the cause or causes of this condition and to relieve adequately the sufferers from back pain has made this one of the most fertile fields in the category of human ail ments for exploitation by the many unqualified to treat the condition It is not the purpose of this chapter to offer physical therapy as a cure-all for these back conditions.

For the physician who is seeing the occasional back condition or who is unfamiliar with the rather intricate methods of diagnosing or differentiating between the various back lesions physical therapy may come as a new and easy experiment to be tried out on such cases Undoubtedly a certain per cent of his patients will be benefited but a large per cent will be unrelieved and disgruntled not only with the physician but with the method

For the physician who is prone to diagnose low back pain as a "sacro-iliac disease," or a painful back following injury with negative x ray findings as a "back strain or a slipping vertebra or "slipping sacro-iliac, and who has developed the habit of treating all these con ditions by the rather simple method of applying a back brace or a special belt physical therapy may be frowned upon as a time wasting needless procedure True rather a high percentage of his cases may be relieved of their back pain but in a large number such a procedure gives too prolonged a disability and leaves many a working man more or less permanently disabled due to the stiffening of the back muscles ligaments and aponeuroses.

For the surgeon who is thoroughly versed in the diagnosis and treat ment of back lesions who has tried out all the old methods of traction casts sacro-iliac belts and back braces and who has seen the high percentage of failure to relieve many persistent low back pains or to prevent permanent disability in many compression fractures there has been a growing tendency to resort to operative procedure viz. bone grafts or other bone-bridging methods Such a one if he has become wedded to operative procedures may fail to give the time and energy necessary to carry out a thorough course of physical therapy before subjecting his patient to surgery

From the advertisements in lay journals and from some of the therapeutic claims made by the manufacturers of certain physical therapy apparatus it is evident that the pretensions of this form of therapy equal or surpass the fraudulent claims made for drug therapy in the palmy days of patent medicines

It may be asserted that the medical profession has no priority rights to massage, electrotherapy mechanotherapy or other physical therapy measures but when it comes to dealing in human health and human life no lay institution and no individual be he physician or otherwise has a moral right to practice this or any other form of therapy without a thorough knowledge of diagnosis and an adequate understanding of the given therapy

Review of the medical literature of the last two decades reveals the vast amount of thought and effort that has been given to this question of disabling back conditions Many theoretical explanations have been advanced by various authors to explain the causes of disabling back conditions especially the low back pain These theories have been adopted as positive facts by the profession Thus we have run the gauntlet of "sacro-iliac slipping sacro-iliac sprains or sacro-iliac disease or displacements Then came the diagnosis of 'lumbosacral sprain and its differential diagnosis from sacro-iliac sprain" More recently the weight of opinion has swung from this mechanical or anatomic explanation for these conditions to a systemic or toxic basis and thus the theory has been advanced that the true cause for many of these low back pains is a "myofascitis Still more recently we find great weight being given to faulty posture and to the abnormal anatomic construction of the spine. During the last two years almost every report of a roentgenogram of the back refers to the relationship of the fifth lumbar vertebra and the sacrum and a faulty angle at this joint is frequently assumed to be the cause of the trouble

Many of these diagnostic titles are still recognized by the profession as real conditions while others have been discarded or are not recognized as of real importance

Schauffler [1] sums up the situation as follows

> Careful attention to the history and to the mode of onset and course of the back pain will help to decide whether one is dealing with a sprain or a mechanical strain. For years sacro-iliac displacements or sprains have been overplayed. Then the honors were divided between lumbosacral and sacro-iliac sprains or they were simply said to be a low back sprain. Now the pendulum has swung far to the opposite side and many articles in recent literature claim that all these back pains are toxic. Myofascitis is the popular term
>
> As always the truth lies between th extreme views. There are lesions purely mechanical and any associated inflammation is of a traumatic type and not at all of a bacterial type. There are many others which are purely

The physician who is willing to treat back lesions, although he is not completely satisfied with his diagnosis, too often uses inadequate physical therapy measures because he likewise has an unsatisfactory understanding of real physical therapy methods. Thus I have seen patients who for months have gone to physicians for only diathermy treatments or for light treatments without receiving any benefit.

The physician who is accustomed to use back braces or special back belts will find physical therapy, if used properly and for the purpose of maintaining function in a group of joints that are held immobilized by the mechanism an invaluable adjunct to his usual procedure.

Most surgeons hesitate a long time before ankylosing one of the joints of an extremity Two or three joints of the back, however can be ankylosed without any great loss of function because of the great number of back joints The loss of function when resulting usually comes from the prolonged fixation of the after treatment. Nevertheless this operation on the back is an extremely major affair, fraught with real dangers in many of our hands and should be used only as a last resort. The usual nonoperative surgical procedures, combined with carefully supervised and adequate physical therapy will obviate many such operations. When it is necessary and is performed the same carefully directed physical therapy will prevent loss of function in the remaining back joints and will hasten the ultimate recovery

During the last decade physical therapy has received very extensive consideration by the medical profession. Many rather extravagant claims for its usefulness have been made within the profession, as well as from many sources outside the profession. Some form of physical therapy usually requiring complicated and often expensive machines for its administration has been advocated for almost every known disease. Here again these back conditions have proved a fertile field for the so-called "physiotherapist."

Almost every community of any size now has one or more nonmedical institutions for the administration of various forms of physical therapy Here is an actual advertisement typical of such institutions

Keep Fit

with

Electrical Cabinet Treatments
Colonic Therapy
Medical Massage
Hydrotherapy
Electrotherapy
Corrective Gymnastics
Weight Correction
Vapor and Sulphur Baths
X Ray Treatments
Medical Baths

therefrom, and consequently injuries of the spine are liable to be complicated by involvement either of the spinal cord itself or of the emerging nerve roots. Furthermore it is probably owing to the presence of the spinal cord that injuries of the spine are particularly liable to be followed by functional disorder

Musculature.—The apparently complicated arrangement of the muscles of this region may be partly simplified by dividing them into separate layers Of these, the first two appertain to the upper extremity including the shoulder girdle, and the fourth and fifth layers are more truly spinal

First Layer Trapezius latissimus dorsi

Second Layer Levator anguli scapulae, rhomboids

Third Layer Serratus posticus superior and inferior splenius colli and capitus

Fourth Layer Sacral and Lumbar Regions—Erector spinae

Thoracic Region Iliocostalis accessorius, longissimus dorsi spinalis dorsi

Cervical Region Cervicalis ascendens, transversalis cervicis trachelomastoid complexus biventer cervicis spinalis colli

Fifth Layer Semispinalis dorsi semispinalis colli, multifidus spinae rotatores spinae interspinales extensor coccygis, intertransversales, rectus capitis posticus major and minor superior and inferior oblique

At first sight such a bald recital of the different muscles as given in text books of anatomy is confusing and even irritating Let us, therefore, endeavor to simplify the problem as follows

Fourth Layer The erector spinae" has a strong tendinous origin from the iliac crest, the sacrum and the lumbar spines and divides into three muscular masses.

The outer—the sacrolumbalis, with its prolongations musculus accessorius, and cervicalis ascendens—is attached to the angles of the ribs

The middle—the longissimus dorsi with its prolongations transversalis colli and trachelomastoid—is attached to the transverse processes of the vertebrae

The inner—the spinalis dorsi with its prolongations—is attached to the spinous processes of the vertebrae

Fifth Layer The greater part of the muscles constituting this layer forms a mass which fills the space between the transverse and spinous processes of the vertebrae and the general direction of the fibers is oblique The inter transversales pass between the transverse processes of adjacent vertebrae and the interspinales between the spinous processes The semispinalis dorsi and colli the multifidus spinae and the rotatores spinae pass obliquely between the transverse processes and the vertebral spines The more superficial bundles pass over several vertebrae, while the deeper bundles pass between adjacent vertebrae.

Lumbar Aponeurosis.—Many cases of prolonged disability are caused by injuries of this aponeurosis or rather by injudicious treatment of such injuries by prolonged rest until adhesions and scar tissue have formed in and about this structure or its extensions

toxic a myofascitis or arthritis is similar to muscular or joint rheumatism in the limbs or to a toxic neuritis In the back there is also a large group of a mixed type. Posture was a predisposing cause, or injury an exciting cause, but the toxic element is responsible for the continuance of the trouble.

It is evident therefore that before an adequate line of treatment can be developed for injuries of the back, a clear understanding must be had of the diagnosis and differential diagnosis of not only the trauma but all associated conditions which might influence the back disability

Anatomy of Back.—The anatomy of the back must be thoroughly understood if one is intelligently to treat injuries of the back. A review of the regional anatomy once or twice a year is not too much to ask of the surgeon caring for back conditions I am opposed to one's becoming simply a "back specialist." There is too great a tendency to interpret all general and local conditions in terms of back disease or injury One must be a good general surgeon if he is to meet the many surgical problems presented by back injuries Again, there are frequently associated injuries in distant parts of the body, in the skull, the extremities the abdomen (as a ruptured liver or kidney or bladder) requiring general surgical knowledge which cannot be met by the genuine "back specialist."

SPINE.—The surgical anatomy of the spine has been written by many excellent anatomists and clinicians Rather than repeat the salient features of these articles the following quotation is taken from Fisher's book on *Manipulative Surgery* [2]

A brief reference to some special points in the surgical anatomy of the spine and to the normal range of movement possible in the different regions thereof is an indispensable preliminary to any discussion of the conditions therein which are amenable to manipulation and of the manipulation technic involved. For the general anatomy of this complicated region the reader is referred to the textbooks of anatomy As, however, the latter but rarely give any reliable information upon the movements of the spine a brief account will be given in which we shall follow the admirable observations of Lovett.

The spine is an elastic column, the strength of which depends on the fact that it consists of a number of vertebrae, the degree of movement between individual bones being slight, but the sum of movement is considerable. The arrangement of the spine in a series of curves also gives far greater strength to the spine for a vertical force is decomposed by the curves. The weakest mechanical point in the spine is where the comparatively rigid dorsal spine meets the more mobile lumbar portion

The prolonged nature of the disablement following many spinal injuries is not difficult to understand if we bear in mind the extreme complexity of this region and the multiplicity of the joints, ligaments, and muscles connected therewith. The important fact must never be overlooked that the spinal cord traverses the neural canal of the vertebrae and that important nerves emerge

physiologic curve can be increased slightly the greater part of the apparent movement occurring at the occipito-atlantal joint.

Lateral Flexion.—As we have seen this movement is always combined with a certain amount of rotation, but the lateral flexion factor is most marked in the lumbar zone It is interesting and important to note that when the spine is flexed lateral flexion occurs at a higher level in this region, and at a lower level when the spine is hyperextended

Rotation.—In striking contrast to the lateral flexion element the rotatory element is almost negligible in the lumbar region, but is most marked in the dorsal and cervical region. It is not difficult to understand why this should be so if the reader will glance at the shape of the articular processes in the different zones. Here again when the spine is fixed rotation occurs at a higher level than in the erect position but when the spine is hyperextended at a lower level Thus, by altering the degree of flexion or extension of the spine, the effect of rotation and lateral flexion can be brought to bear on successive spinal regions.

FIG. 1.—Congenital absence of upper left transverse process of sacrum. Weak back for years. Recently suffered slight injury with marked increase in back pain

Pathologic Conditions.—The following classification is one adopted by the author for the purpose of depicting the pathologic possibilities in the spine itself as well as those pathologic conditions which are extraneous to the spine but which may cause referred pain in the back

I CONGENITAL DEFECTS

A. Absence of a vertebra or portions of one or more vertebrae (Fig 1)

1 Spina bifida occulta

LIGAMENTS —These are exceedingly numerous and for their detailed description a textbook of anatomy should be studied. It will be sufficient merely to mention that not only are there ligaments which stretch between the vertebral bodies (anterior and posterior common ligaments and intervertebral discs) but also ligaments which connect the articular processes, laminae, spinous, and transverse processes Further there are ligaments connecting the heads of the ribs with the bodies of the vertebrae and others connecting the necks and tubercles of the ribs with the transverse processes. In the upper cervical and lumbosacral region there are other important ligaments having special functions.

SPINAL SURGICAL LANDMARKS —A few of the most important and essential of these are given Five minutes spent in committing them to memory will be amply repaid

Root of Spine of Scapula Interval between third and fourth dorsal spines
Inferior Angle of Scapula Interval between seventh and eighth dorsal spines
Highest Point of Iliac Crest (Interiliac Plane) Fourth lumbar spine
Posterior Superior Iliac Spine Second sacral spine
Spinal Cord Ends First lumbar spine (transpyloric plane)
Spinal Theca Ends Third sacral spine

MOVEMENTS OF THE SPINE.—The actual movements in the spine itself are really less than might at first sight be assumed on observing full forward flexion for a considerable amount of the apparent movement is pelvic and takes place at the hip joints and some of the movement occurs between the skull and the spine.

If we are desirous of ascertaining the actual movements of the spine itself, some means must be taken of fixing the pelvis, and correction must be made for movement at the occipito-atlantal joint Similarly if exercises and passive manipulations are performed which are intended to act upon the spine alone, the pelvis should be fixed.

The actual movements may be divided into flexion extension, and a complicated movement—lateral flexion rotation There is no such movement as a pure lateral flexion for a certain amount of rotation inevitably accompanies this. Similarly rotation is always accompanied by a certain amount of lateral flexion It is important to remember however that there is a variation in the degree of the rotatory and the lateral flexion elements, respectively in the various regions of the spine The nature of the movements is largely influenced by the shape and the direction of articular surfaces.

Flexion (*Bending Forward*) —This movement is most marked in the lumbar region and is possible until the normal forward convexity is practically obliterated. The movement is more marked therefore, in the lower part of the lumbar region In the cervical region flexion can occur until the physiologic curve is obliterated Most of the apparent movement of flexion really occurs at the occipito-atlantal joint. In the dorsal region forward movement is very slight but the normal convexity backward is slightly increased

Extension (*Bending Backward*) —This movement is most free in the lumbar and the two lower dorsal vertebrae. Very little movement in this direction occurs in the remainder of the dorsal region and in the neck the

II. Postural and Acquired Defects
- A. Kyphosis
- B Scoliosis
- C Lordosis
- D Spondylolisthesis
- E. Dorsal round back
- F Posterior displacement
- G "If the spinal column is not deviated laterally and its normal lordotic and kyphotic anteroposterior curves are not exaggerated if the spinal curves which are associated with the habitual posture of the individual are not so extreme as to threaten or produce joint and muscle strain or disturbance of the visceral relations if the posture is such that there still remains a margin of 'safety' which allows more mobility in all directions the spinal curves and the weight bearing lines of the lower extremities may be said to fall within normal limits for the individual under consideration"[3]

III Diseases of the Back
- A In the spinal column proper
  - 1 Osteo arthritis
    - (a) Usually hypertrophic
    - (b) Ankylosing arthritis (Strümpell Marie disease)
    - (c) May be destructive type
    - (d) Of unknown infectious origin
    - (e) Neisserian
    - (f) Toxic, traumatic
  - 2 Synovitis (lateral articulation)
  - 3 Osteomalacia
  - 4 Kümmell s disease
  - 5 Vertebral epiphysitis
  - 6 Herniation of intervertebral disc
  - 7 Abscess of disc
  - 8 Spondylitis
    - (a) Tuberculosis
    - (b) Osteomyelitis
    - (c) Syphilis
    - (d) Typhoid spine
    - (e) Sporotrichosis, etc.
  - 9 Tumors
    - (a) Usually metastatic carcinoma
    - (b) Sarcoma
    - (c) Giant-celled tumors
    - (d) Hypernephroma
    - (e) Hemangioma of vertebral bodies

2 Hemivertebrae
3 Klippel Feil syndrome (absence of two or more cervical vertebrae)

B Extra vertebrae
1 Eighth cervical
2 Sixth lumbar
3 Fourth lumbar

C Faulty angulation of fifth lumbar on sacrum—a congenital spondylolisthesis

Fig. —Sacralized 5th lumbar vertebra on left side.

D Sacralized fifth lumbar (Fig 2)
E Elongated fifth transverse process definitely impinging upon or articulating with the sacrum or ilium
F Cervical ribs
G Malpositions of the coccyx
H Separate neural arch
I The slender individual with almost a straight spinal column the long waisted type seen most frequently in the neurotic or in subjects prone to develop functional disorders

3. Contusion of the cord
4. Hemorrhage into the cord
5. Tearing of the nerve roots
   (a) Brachial plexus evulsion
   (b) Cauda equina lesions

C. Surrounding the spinal column—Soft tissue injuries
   1. Strains—traumatic lumbago or myofascitis

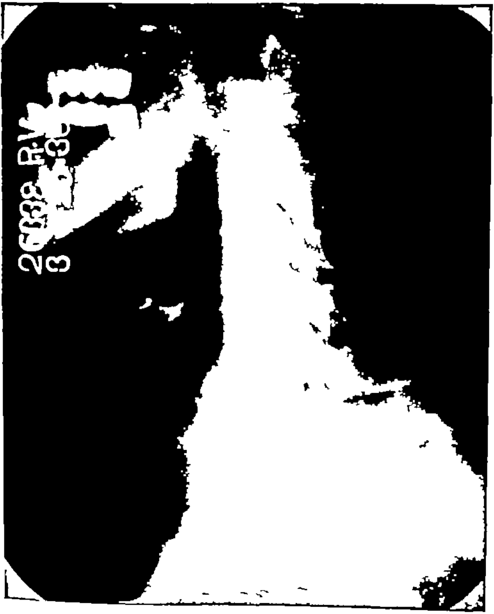

Fig. 32—Fracture of st cervical ertebra—lateral view

- B Within the spinal canal
  - 1 Spinal meningitis
  - 2 Spinal syphilis
  - 3 Tabes dorsalis
  - 4 Syringomyelia
  - 5 Multiple sclerosis
  - 6 Cord tumors
  - 7 Poliomyelitis and myelitis
  - 8 Cord changes due to pernicious anemia
  - 9 Extradural abscess
  - 10 Myeloma
  - 11 Vertebral artery aneurysm

- C Surrounding the spinal column
  - 1 Muscular rheumatism, myositis myofascitis (lumbago)
  - 2 Psoas abscess or mediastinal abscess
  - 3 Boils carbuncles or abscesses with scar tissue formation
  - 4 Osteomyelitis or tuberculosis of sacro-iliac joint
  - 5 Tumors of soft tissues of back
    - (a) Lipomas
    - (b) Pilonidal cysts
    - (c) Malignant tumors
  - 6 Progressive muscular atrophy
  - 7 Neuritis
    - (a) Herpes zoster
  - 8 Bursitis

IV Injuries of the Back

- A. In the spinal column proper
  - 1 Fractures of body or lamina
  - 2 Dislocations
  - 3 Fracture-dislocations (Figs 3a 3b)
  - 4 Fracture of spinous or transverse process
  - 5 Dislocation at vertebral costal joint
  - 6 Inpingement of eleventh and twelfth ribs
  - 7 Impingement of spinous process
  - 8 Sprains
    - (a) Sprain fracture at tip of transverse process
    - (b) Associated with partial displacements or rotations
    - (c) Tearing off of osteo-arthritic spur
  - 9 Partial displacements
    - (a) The atlas upon the axis
    - (b) Lumbosacral

- B Within the spinal canal
  - 1 Compression of the cord
  - 2 Laceration of the cord

D Sacro-Iliac
- (a) Strains
- (b) Sprains
- (c) Partial dislocation
- (d) Complete dislocation
- (e) Traumatic arthritis
- (f) Associated with fractures in the pelvic girdle

E Coccyx
- (a) Fractures
- (b) Dislocations
- (c) Contusions

V Possible Types of Associated Injuries with Traumatic Back

A. Head
1 Skull fracture
2 Cerebral injuries

B Chest
1 Fractured ribs
2 Penetrating wound of lung
3 Pleuritis
4 Injuries of scapula

C Abdomen
1 Rupture of mesentery
2 Rupture of liver
3 Rupture of spleen
4 Rupture of kidney
5 Rupture of stomach or intestine
6 Contusions of one or more of these viscera
7 Rare injuries to gallbladder or pancreas

D Pelvis
1 Fracture of pelvis
2 Rupture of bladder
3 Rupture of ureter
4 Contusion of urethra
5 Bladder and rectal disturbances
6 Rare injuries to pelvic viscera

E. Extremities
1 Brachial plexus irritation paresis or paralysis
2 Sciatica
3 Paresis o paralysis
4 Fractures in one or more extremities

VI Other Diseases Which May Cause Painful or Pathologic Backs

A Focal infections
1 Tonsils

2 Sprains—tearing of ligaments
3 Adhesions about the joints or in the lumbar aponeurosis
4 Muscle changes
  (a) Tearing of muscles
  (b) Fibrositic deposits
5 Peripheral nerve injuries near exit from spinal column
6 Traumatic wryneck
7 Contusions
8 Hematoma
9 Burns
  (a) Scar contractures
10 Foreign bodies
11 Penetrating and lacerating wounds
12 Lumbar hernia

Fig 3b —Anteroposterior view shows slight lateral dislocation

C. The injury may aggravate existing disease
 1 Osteo-arthritis of spine
 2 Myofascitis
 3 Tuberculosis of spine
 4 Aggravating a preëxisting deformity
  (a) As in an old infantile paralysis

It is evident from the above outline of the more common pathology involved in this question that the diagnosis and the differential diagnosis of back injuries and back disease furnish some of the most complicated problems found in medicine.

Diagnosis.—The gross lesions of the back following trauma such as a definite compression fracture or a dislocated vertebra are not difficult to diagnose provided proper attention is paid to the history of the injury and to the complaints of the patient and suitable x ray pictures are taken. Even in these conditions a thorough general examination is necessary to discover associated injuries or signs of associated disease postural defects or infectious conditions which may aggravate the injury and be of great importance in the prognosis

Since Davis (Vol II) deals with spinal cord injuries which usually follow fractures or dislocations of vertebrae, conditions of this type will not be considered in this chapter

The less serious back traumas are far more difficult to diagnose So many associated conditions both in the spinal cord and in the general systemic examination have a potential influence that it requires the greatest ingenuity on the part of the examiner to differentiate between these and the alleged trauma.

History —The history of the case is of the greatest importance in diagnosing these back injuries If the patient is brought into the hospital following a major accident for example after a head-on collision between two automobiles the history develops potentialities for all kinds of major and minor injuries to the individual Here a careful physical examination is made of the head neck chest abdomen back pelvis and extremities and often a catheterized specimen of urine is obtained to ascertain the condition of the kidneys bladder and urethra The x ray is brought in as a diagnostic aid *as soon as the condition of the patient warrants* The injury to the vertebra is discovered either as the sole injury or as associated with a skull fracture fractured ribs a fractured pelvis or other injuries

However in those disabling back conditions which fail to show definite x ray pathology or which develop several days after the alleged injury the history assumes greater importance How severe was the injury? When was it received? Was the injury due to a direct or an indirect force? Has the patient been subject to backache? Have there been previous injuries to the back and if so what was their nature.

2 Teeth
3 Sinus infections
4 Acute or chronic infections anywhere in the body

B Aneurysm or tumors
1 In chest
2 In abdomen
3 In pelvis

C Abdominal conditions
1 Gallbladder disease
(a) Referred pain during gallstone colic
(b) Constant back pain may be only sign of gallstones
2 Appendicitis—especially retrocecal appendix
3 Ulcer of stomach
4 Colitis especially spastic constipation
5 Diverticulitis, especially of sigmoid
6 Hernia

D Kidney conditions
1 Perinephritic abscess
2 Kidney or ureteral stone
3 Twisting of pedicle of kidney—Dietl's crisis

E Retroperitoneal conditions
1 Tumors
2 Enlarged glands

F Pelvic conditions
1 Displacements of uterus occasionally
2 Tumors of uterus
3 Infections of adnexa
4 Cysts of ovary—twisted pedicles
5 Prostatic disease
(a) Inflammatory
(b) Tumors

VII. Any of the Above Diseases May Exist at the Time of a Given Injury to the Back

A The injury may be only coincidental, neither aggravating nor contributing to the disease
1 As in metastatic carcinoma of spine
2 As in gallstones
3 As in tumor of abdomen or of prostate

B The injury may be a contributing factor
1 As in osteomyelitis of spine
2 As in twisted pedicle of ovarian cyst
3 As in acute gallstone colic developing shortly after injury
4 As in acute retrodisplacement of uterus coming on immediately after injury and persisting until relieved by manual replacement

into varied types of traumatic neuroses It is sometimes extremely difficult to distinguish between the true organic and the functional condition or properly to evaluate each when there is a mixture of both in the same case

X Ray —The x ray is invaluable in the diagnosis of back injuries It is too often neglected in cases resulting from rather minor accidents or is not resorted to until weeks or months later The late x ray may show osteo-arthritic changes or other findings and because of the failure to take the earlier x ray one is unable to say definitely that this or that condition was preëxistent and that it has no relationship to the alleged injury

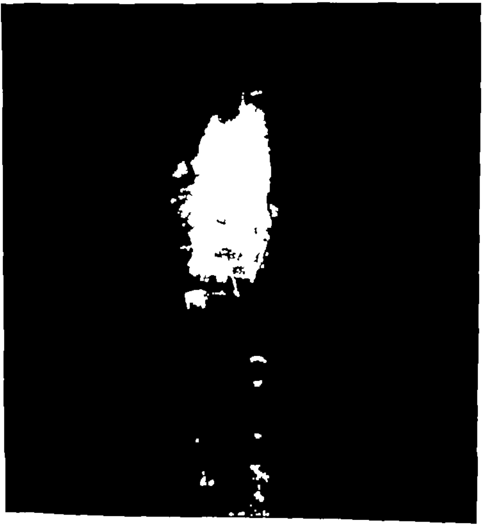

Fig. 42 —Anteroposterior view of the spine made at time of injury in Michigan. Diagnosed as negative for fracture

and when? What was the position of the patient when injured—sitting, standing, bending over, or erect? Has he had recent toothache or tonsillitis or have teeth been pulled or the tonsils removed recently? Has he been subject to colds or sinus trouble? What is the condition of the bowels? Has appendicitis been diagnosed or an appendectomy performed? Has he been jaundiced? In the case of a woman, have there been any pelvic complaints? In the case of a man, is there a history of urinary or prostatic trouble? Has there been any marked loss or decided gain in weight recently? Has there been any foot trouble or pains in the calves of the legs or thighs? What is the exact nature of his or her work? Has there been any recent change from sedentary to heavy occupation? What have been the past illnesses? What is the family history?

These and every other possibility which might throw light upon the alleged back disability must be delved into in the history

Physical Findings —The complete physical examination is of equal or usually greater importance If the case is one from a major accident the examination starts with the head and includes every part of the body that might have been injured, followed by a careful routine examination as soon as the condition of the patient permits. If the patient complains of back disability from an alleged trauma, the injured part is first examined and this is followed by a painstaking complete general examination Each physician should develop a fixed routine for this or any other examination in order not to overlook any part.

If the patient is in bed it may be difficult to turn him over for an examination of his back but this should be done if at all possible care being taken to avoid undue pain of movement or the danger of increasing his trauma. If the case is ambulatory the examination is best started with the patient sitting on a stool Later he should stand and, finally he should be in the prone position on the examining table.

Close but unobtrusive observation of the patient should be made during the taking of the history while he is undressing and during the examination. Often data will be obtained in this way which will be invaluable in arriving at a true diagnosis

In the case of a severe trauma to the spine, for example, a compression fracture one seldom encounters signs or symptoms of neurosis if it has been properly treated. On the other hand the signs and symptoms in some of these less severe back injuries are so obscure or so difficult for the patient to express or give such atypical complaints that there is too often a tendency on the part of the physician to classify the case as one of traumatic neurosis Unquestionably many back injuries due to failure to receive relief after many changes in physicians and in the lines of treatment or due to inherent fears of a "broken back" or due to a desire for compensation for their suffering abetted frequently by overzealous relatives or lawyers do develop

x ray both views being taken within two to four weeks and still another being made within a few weeks thereafter if necessary Too often the compression fracture will not show on the first films but the compression gradually occurs due to movement or weight bearing and the later film reveals the true condition In the case of persistent trouble the second third or even the fourth film will be the only means of diagnosing the traumatic arthritis or the secondary tumor that, rather than some minor injury which was coincidental most probably was the original cause of the back pain

The following case reports illustrate these points concerning x ray examination

CASE 1 —Dr T aged 52 attended a medical meeting When he sat down the chair slid from under him. As he fell forcibly to the floor the back of the chair struck him in the mid-dorsal region. He was immediately in excruciating pain and was carried to a couch in the anteroom. As soon as the essayist, a noted surgeon, was through, he went to the injured doctor examined him through his shirt felt a swelling over his mid-dorsal spine, and advised that he be taken to the essayist's hospital at once for what was most probably a subluxation of a dorsal vertebra The patient was moved to this hospital and early the next morning x ray pictures—both views—were made of his spine. An hour later the surgeon and the roentgenologist came to the patient's room bringing the x rays with them and told him that nothing was broken or dislocated in his spine and that he would be all right after a few days rest. No further examination was made by this surgeon The doctor suffered severely and required morphine for four or five days He had a special nurse who rubbed his back but otherwise no treatment was given. At the end of a week the patient called an excellent internist. He examined the patient thoroughly and also examined the x rays. His findings revealed almost complete absence of breath tones in the left chest tenderness over the mid dorsal vertebrae, a spasm of the muscles on attempted deep breathing and an extremely nervous individual During the second week the surgeon began to plague the doctor about being a "neuro and the latter sensed this to be the feeling of most of the hospital staff Therefore, on the advice of the internist he left the hospital on the fifteenth day going to his home On the sixteenth day fearing that perhaps he was a "neuro" this doctor got up and dressed and went to his office in a taxicab He could hardly stand the jolts of this ride and after a few hours in his office he collapsed The pain was extreme and he could hardly breathe. He was taken home and the internist was called who again found a spasm of the back and chest muscles on the least effort at deep breathing He advised the doctor to remain in bed. The internist again visited the hospital and examined the old x-rays but could find no sign of injury to the vertebrae The doctor remained in bed for a month although after a week he could be helped to the toilet By the end of the month the internist agreed with the original surgeon that this was a case of neurosis. His opinion was strengthened by the fact that the doctor planned a lawsuit against the hotel where the meeting was held holding a defective chair responsible for his injuries.

After another month the internist asked the author to see this doctor stating that while he was a "neuro yet he might have some injury to his back.

Always x ray the spine at the site of the alleged injury when the patient first presents himself If the site of the injury is not definitely localized x ray well above and below the injured part In many cases it is safer to x ray the entire spine.

It is still necessary to emphasize and reëmphasize to the profession the importance of taking *both* an *anteroposterior and a lateral view of every spine requiring* an *x-ray no matter whether for an injury or for a suspected disease* Hardly a month goes by that I do not see one or more patients with a definite vertebral injury who has been in the

Fig 4b—Same case with lateral view made three weeks later showing marked compression fracture of 12th dorsal vertebra.

hands of some other physician and who has had an x ray examination yet, when he is x rayed at our hospital the lateral views show a compression fracture Asking for and examining the first x ray films we find that only an anteroposterior view had been made This failure to take the lateral view accounts for far too many failures in diagnosis and far too many cases of prolonged back disability due to inadequate treatment (Figs 4a 4b)

Again if the first x-ray picture is negative and yet the signs and symptoms of injury persist one should always resort to a second

The doctor was rather difficult to treat but gradually recovered from his pain and discomfort under rest heat, massage, and a body corset

This case illustrates the failure to secure a complete history or to give sufficient weight to certain facts in the history the failure of the original surgeon to examine the patient thoroughly the failure to take a second x ray when the signs and symptoms persisted and finally the failure to treat the case adequately because of failure properly to

FIG. 5b—Lateral view f and ray of same case taken four months later showing a marked compression fracture of 8th dorsal vertebra

It took three-quarters of an hour to secure a complete history from the patient Examination showed a definite knuckle deformity over the eighth dorsal vertebra He had several variable tender vertebrae, but the tenderness was always constant and marked on pressing over this eighth dorsal. At the writer's suggestion he was taken to St Luke's hospital the next morning for an x ray and possible treatment

The x ray examination the next day showed in both views a very marked compression fracture of the eighth dorsal vertebra (Figs 5a, 5b) Later I examined the original x rays and agreed that they failed to show this fracture.

Fig 5a —Lateral view of first ray taken the day f llowing the injury and showing no fract re

The doctor was rather difficult to treat but gradually recovered from his pain and discomfort under rest, heat massage and a body corset.

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Fig. 3b—Lateral view of 2nd x-ray of same case taken four months later showing a marked compression fracture of 8th dorsal vertebra.

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FIG. 5a —Lateral view f first x ray taken the day following the injury and showing no fracture

TRAUMATIC LUMBAGO MYOFASCITIS —The differential diagnosis between the traumatic back and certain diseased conditions is not always easy but is of prime importance both in prescribing treatment and in those cases of a medicolegal character where the honest opinion of the surgeon is necessary in deciding between liability and non liability compensation and noncompensation

In the case of a slight injury followed by a painful low back the question as to whether this is a "rheumatic lumbago" or a 'traumatic

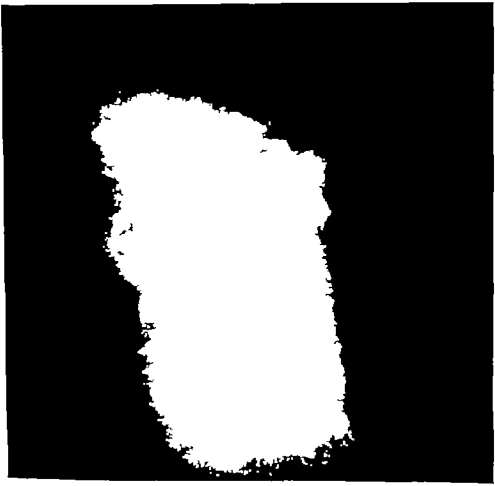

FIG. 6—Lateral view of spine in case f Mr B showing compression fracture f first and third lumbar vertebrae.

lumbago" is answered with difficulty Muscular rheumatism or a myofascitis very frequently attacks the erector spinae muscles. If the patient states that he was lifting when the attack suddenly started or that he was carrying a heavy desk with a fellow employee who dropped his end of the desk, throwing all the weight of the desk upon the patient, or that he slipped upon some grease while walking through

diagnose the condition The mistake of calling him a "neuro" is the usual mistake when all these failures are present.

CASE 2 —Mrs M., aged 40 married, sustained a fall of little consequence in March 1929 Approximately two weeks later she complained of pain in her lower back A good surgeon was consulted and after obtaining this history of falling and after examining her and finding pain and tenderness near the left sacro-iliac region, he had an x ray picture made This was negative. The diagnosis of sacro-iliac sprain was made and the patient was treated with heat massage and strapping. The pain persisted and finally, after five months of treatment without relief the surgeon made another x-ray examination. This film showed a marked metastatic carcinoma of the left ilium, near the sacro-iliac joint.

Together with the surgeon I saw this patient and helped to explain to the husband that his wife had a hopeless incurable condition and tried to make him understand why it showed in the second x-ray when it did not show in the first one. Of course, the condition could have been discovered earlier by the principle laid down above, viz.—*If a condition persists and the first x-rays were negative repeat the x-ray within four weeks and repeat again in a few weeks if necessary*

CASE 3 —Mr B., aged 60 an engineer fell from his engine and struck his back across a rail He was carried to his home and the doctor was called. Examination was negative but the doctor suggested that if the patient was still in pain the next morning, he would take him to the hospital for an x-ray The next morning however the patient was better and no x ray was taken then or at a later date. After a week this patient got out of bed and limped around the house and yard but always complained of pain in his spine when he tried to get up from bed or from a chair and again when he tried to sit down. After six months he was sent to me for an examination, with the statement from his doctor that the old man was making too much out of his injury and wanted to get a pension.

The history was important, namely the fall across the rail. The patient acted perfectly natural and showed none of the earmarks of exaggerating his complaints The examination showed a definite spasm of the muscles in the lumbar region when he attempted to rise from the sitting position. Palpation over the vertebrae showed no variable points of tenderness but always a constant point of tenderness over the third lumbar vertebrae. The x-ray examination confirmed my diagnosis of compression fracture of the third lumbar vertebra There was also a compression fracture of the first lumbar These fractures however did not show upon the anteroposterior view and without the lateral view would have been missed (Fig 6)

The failure to take an x ray here resulted in a wrong diagnosis and later to the patient's being called a "neuro or exaggerator

Differential Diagnosis.—One must be alert to discover diseased conditions of the spine which simulate in their early stages at least, the traumatic back.

Examination showed an old man who was definitely suffering pain. The back examination was negative except for some limitation of motion that could easily be due to osteo-arthritis and for a definite constant point of tenderness in the region of the fourth lumbar vertebra. The rectal examination revealed an enlarged, indurated prostate that was undoubtedly malignant
X ray examination showed a destructive process in the body of the fourth lumbar vertebra.
Diagnosis was readily made of primary carcinoma of the prostate with a secondary growth in the vertebra.

The complete physical examination, including the rectal examination combined with the later follow-up x ray examination made it possible to differentiate this from an accidental or traumatic condition It likewise saved the village of R—— a considerable sum of money when suit was brought to collect damages for the alleged accident.

Disproving Alleged Stiffness —I have mentioned the importance of unobtrusively observing a patient carefully during the examination Occasionally a patient will complain of stiffness in the back and during the examination will show definite limitation of flexion movement. When the examination is completed see that the patient s clothes are lying on the floor Tell him to dress and then apparently leave the examining room or otherwise seem to pay no attention to the patient. Occasionally such a patient will lean over and pick up his clothes showing that now that the examination is over his back is not nearly so stiff as it was during the examination

One of my favorite ways of disproving an alleged stiffness in the back is the following I slip on a glove and tell patient that I want to make a rectal examination. The patient is placed in front of a low table or chair finger is inserted in the rectum and of course it is painful patient is told to lean over the table or chair and it will not be so painful. The examination is kept up until the patient has flexed his back equal to any normal flexion These and many other methods can be adopted to prove the neurosis or malingering cases.

Diagnosis has been considered at length before taking up the problems of treatment because of the surprisingly large number of these back injuries which receive various lines of treatment although no definite diagnosis of the real condition has been made I have seen many patients who should have been in bed at absolute rest, going daily to a doctor's office for physical therapy treatment, namely quartz light treatment or more often diathermy or in some instances baking and massage Some of these patients have had compression fractures undiagnosed Other patients with trivial injuries have been kept in bed for weeks or fitted with a Taylor belt or given physical therapy treatments usually light or diathermy and have developed true neuroses chiefly because of overtreatment. Therefore one cannot write concerning the traumatic back without emphasizing the importance of diagnosis The two must go hand in hand

the factory, if there were witnesses to this slight accident and finally if the examination reveals a definitely lame back, then it is practically impossible to disprove the injury element. Even if there is a past history of lumbago and the findings are definitely those of lumbago the slight accident can be held to be an aggravation of an existing condition. On the other hand, if the patient gets a sudden attack of lumbago when arising from bed or upon turning over in bed, or following a Saturday afternoon of helping his wife clean house, then the question of accident seldom arises and the case is clearly one of "rheumatic lumbago" As a rule, both conditions are exactly the same. In these indefinite back conditions the question of injury would not be raised so often if an accident insurance policy or an employer's liability law was not involved

Posture, Body Mechanics, Flatfoot —In all cases of back injury or backache, especially in the low back pain the surgeon must search for faulty posture, poor bodily mechanics, and such defects as flatfoot. A third degree flatfoot is very frequently the active etiologic factor in the alleged traumatic back, the slight injury being only the exciting or contributing cause Months of prolonged treatment in such cases may be avoided by discovering and stressing the treatment of the flatfoot condition.

Tuberculous Spondylitis —This may be the cause of the pain and disability for which some trivial injury is held responsible The appearance of a psoas abscess may be the first indication which the patient develops to show the true condition

Kümmell's Disease —Kümmell's disease or the development of a traumatic spondylitis months after the injury must be differentiated from the tuberculous spondylitis and from the osteoporotic type of arthritis

In those regions still subjected to typhoid epidemics the "typhoid spine' must likewise be considered in a differential diagnosis

Metastatic Malignancy —This has already been mentioned The spine is a very frequent site for these metastatic malignancies. Early the x-ray may be negative, but one must persist in the x-ray studies of the spine whenever the possibility of this condition is known to exist or can be suspected

Case 4.—M. T., 63 years old, slipped on the ice while working for the village of R—— He completed his day's work but the next day had pain in his back and therefore went to the village physician An x ray was taken but was negative His back was strapped Pain persisted but he was able to work off and on for a few weeks and then was forced to quit. About two months following this alleged accident he was referred to me for examination and opinion as to whether it was a traumatic back, and for suggestions as to treatment

If you have no physical therapy department, get one Do not refer your cases to nonmedical physical therapists or to unsupervised tech nicians or to the club gymnasium or to similar places where you lose the essential control of the patient and the more essential continued interest in his recovery

Spinal Fractures with Cord Injury

Fractures should be divided into those cases having signs and symptoms of cord injury and those without cord injury

Davis (Vol. II) deals with fractures involving the cord and therefore these will not be considered here. However one cannot refrain from pointing out the importance of using physical therapy methods in such cases Many of these cases seem hopeless even after an early laminectomy Nevertheless a certain percentage of the hopeless cases do recover Nothing is more pitiful than to see a patient with a fractured back accompanied by paralysis gradually regaining some power in his legs and yet unable to walk even with crutches because his feet have been allowed to ankylose in an extreme equinus position.

Treatment.—A laminectomy is important but the after treatment of these cases is equally if not more important. Within the first 48 hours some method of protecting the feet from the disabling foot-drop position is essential One can use sand bags or better a padded splint fitted to each foot with an elastic extending from the top of the splint to the leg just below the knee where it is attached by a small piece of tape.

Within the first week light stroking massage of the extremity from the foot to the hip should start. This should never be a heavy massage lest one injure the blood vessels now so poorly protected by the paralyzed muscles As time goes on the firmness of the massage may increase This can be judged by the tone of the muscles

Muscle-training exercises similar to those described in the chapter on infantile paralysis (Legg Vol II) and in the chapter on brain and spinal cord lesions (Davis Vol. II) should start not later than the second week and should be persisted in for months or until the patient can begin to exercise and train his own muscles When this stage is reached occupational therapy planned for a definite purpose will be helpful in improving function The swimming and underwater exercises so well described by Lowman (Vol III) can be utilized in these cases to great advantage.

The following two cases will emphasize the above points

Case 5—M T., aged 40 suffered a compression fracture of the first lumbar vertebra with immediate paralysis of both lower extremities. A laminectomy was performed The patient then lay in bed for eight months, when he was transferred to a wheel chair At the end of a year and a half he entered the surgical service at St. Luke's hospital, under the care

Physical Therapy Axioms for Back Treatment

Given a trivial injury in a nervous individual who shows a tendency to exaggerate his condition, one can often rub in more disabling conditions in a week than he can rub out in a year

In such an individual, as well as in other neurotic types one can employ diathermy, quartz lights, infra red bakers, and similar apparatus to the extent of impressing him with the seriousness of the situation and thereby aggravating the neurosis.

The fitting of a back brace or a sacro-iliac belt is occasionally indicated in certain cases, but in many others such a procedure is equivalent to dooming the patient to a life of invalidism.

It is often more difficult to get patients who have recovered from back injuries to give up their back braces than it is to get some old fractured cases to give up their crutches

If a patient is a compensation case, the back brace often is the etiologic factor in a compensation neurosis. The "railway spines" of yesterday have been replaced by the "traumatic neuroses" of today Given an ambulance-chasing lawyer and his medical cohort who fits such a case with a cumbersome back brace and you have a combination hard to beat.

The spine is made up of numerous joints which are adjacent to the two large sacro-iliac joints Immobilize these joints for any length of time and stiffness is bound to follow Massage and exercise are the two best means of combating ankylosis here as well as in other joints.

He who treats back injuries must know or have access to intelligent physical therapy

Machine therapy alone is not intelligent physical therapy You can turn a "light" on these old back cases from now until doomsday without any effect.

If desirable use a light or diathermy machine to heat the part but follow this with massage, muscle-training exercises and graduated doses of work if you want a cure.

Physical therapy in 90 per cent of the cases consists of equal parts of trained hand work and of ability to get the patient to help himself In the other 10 per cent of the cases it may be necessary to combine with these some form of machine therapy

Common sense and judgment are essential qualifications in using or prescribing physical therapy

"A little knowledge is a dangerous thing" is especially applicable to a technician A talkative technician or one wedded to a given *modus operandi* may drop a remark make a suggestion, refuse to coöperate because her method is better or otherwise sow seeds of doubt fear or dissension in the patient's mind to the extent of nullifying the benefits of the physical therapy treatment

A trained technician may administer but the surgeon must supervise the physical therapy treatment.

of Dr Holmblad The patient could move his legs, but the lower extremities were entirely and markedly atrophied. The knees could be flexed with slight assistance. The feet, however were clawlike and were fixed in an exaggerated equinus position. If the patient was held in an upright position his weight rested directly on the tips of his toes Dr Holmblad fitted leg and thigh braces on this patient with a caliper arrangement which held the feet just off the floor when the patient rested his weight on the base of the calipers Daily massage muscle-training exercises, and lessons in walking with the aid of crutches and the braces comprised the plan of treatment The patient improved in strength but will probably never be able to do without his braces and walking calipers. This is the picture of the patient who received good surgical treatment as far as the laminectomy was concerned but extremely poor or no surgical after-care (Fig 7)

CASE 6 —On visiting a hospital in a nearby city I was invited by the surgeon to inspect the ward cases He showed me a male patient 50 years of age who had suffered a fractured vertebra with cord compression some 11 months previously A laminectomy had been performed. The patient was in good condition but the paralysis of the lower extremities was still complete. A marked foot drop was present and it was impossible to dorsiflex his feet manually This patient even though he should recover would be doomed to be a bed or wheel-chair invalid the rest of his life. This surgeon stated that he did not take much stock in physical therapy

Recent Trauma of Spine without Cord Injury

Recent injuries of the spine without cord lesions can be divided into (a) compression fractures of the body (b) fractures of the transverse processes (c) fractures of the laminae and arches (d) fractures of the spinous processes (e) dislocations and subluxations (f) fracture-dislocations (g) sprains strains vertebral locking etc.

Compression Fractures

Compression fracture of one vertebral body is the commonest type It may be accompanied by similar fractures in other vertebrae or by associated fractures such as fractures of one or more transverse processes The usual mechanism is a forcible flexion of the spine causing a crushing of the anterior portion of the body At times there is a forward displacement of a small wedge of the body of the vertebra.

The immediate surgical treatment of this condition varies from absolute recumbency to operative fixation by bone transplantation across the site of the fracture Between these two extremes many methods of repair are recommended

Personally I have seen very few compression fractures of the spine in which I felt that either an Albee or a Hibbs operation or any other type of bony fixation was indicated Dixon, of Kansas City recently advocated in a clinical meeting more operations early in these cases claiming that better end results followed in his operative cases than

Fig. 7—Photograph of M T (Case 3) who had good surgical treatment of his cord injury but no protection against foot drop

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in those treated by closed methods Chandler, of Chicago, has recently published an article advocating a bone transplant or a Hibbs operation in certain obscure fractures of the lamina.[4] He claims that many cases of persistent back pain are due to these fractures of the lamina which are extremely difficult to demonstrate by x-ray and are, therefore frequently overlooked Other excellent surgeons have strongly advocated open operations The preponderance of opinion still favors the more conservative, closed method of treatment.

Treatment.—The principles of treatment governing these compression fractures are

(a) Correction of the deformity by hyperextension of the spine
(b) Immobilization by recumbency in bed with some device to maintain the hyperextension, in a body cast, with recumbency rest in bed and traction, a body cast that allows the patient to be ambulatory or a specially built back brace
(c) Immobilization and rest for a variable period, ranging from eight weeks to six months

Walsh s Method—Walsh of Pittsburgh, has long advocated the hyperextension treatment of these vertebral fractures and has developed a special bed which can be raised in the middle, thus giving a position of hyperextension to the recumbent patient. Davis, of Erie, has developed a procedure which he claims will overcome the compression deformity of the vertebra and restore its body to normal alignment This method consists of placing a sling about the feet, with a rope or strap passing from the sling through a pulley in the ceiling the anesthetized patient lies face downward and as his feet and legs are raised in the air his weight rests upon the upper chest. Manipulations of the spine are made with the patient in this hyperextended position A plaster bed is then applied directly to the patient while he is still in this position Later this cast can be bisected and the back half removed to permit massage.

Jones' Method—R Watson Jones[5] of Liverpool describes a simple method of securing hyperextension and of immobilization of the fracture as follows

Not only is a general anesthetic quite unnecessary but the position required can be maintained much more easily by a conscious than by an anesthetized patient. Although complaint is made of aching and discomfort in the arms where the weight of the trunk is borne none of the patients complain of pain in the back, so that we have not thought it necessary to adopt Bohler's suggestion of injecting novocaine locally One-quarter or one-third of a grain of morphine is given half an hour before

Two tables are arranged end to end with a space between slightly greater than the length of the patient's trunk The front table is raised on blocks or chairs so that it is about two feet higher than the other although not

essential it is an advantage to use an operating table of adjustable height so that the hyperextension can be attained gradually by screwing up the table after the patient is in position. Throughout the treatment flexion of the spine must be avoided The patient is therefore lifted *face downward* on to the lower table and a double layer of stockinette pulled over the trunk and stitched over the shoulders and beneath the perineum The spinous processes and the iliac crests may be further protected by small pads of adhesive felt, but it is essential that the plaster should fit very closely bulky padding with wool or felt is to be avoided A closely fitting woolen bathing costume is an excellent substitute.

The patient is now assisted into such a position that he is gripping the edge of the higher table with his abducted arms the head resting on a small

Fig 8a.—Example of Jones reduction of compression fracture of spine.

pillow The lower table supports his lower limbs as high as the upper thigh, but between the groins and the neck there is no support. In this position he is unable to prevent his spine from gently sagging into full hyperextension (Fig 8a) The plaster is applied at once, and is well moulded to the curve of the spine the sacrum and iliac crests. The rubbing in of layer after layer of plaster gives just sufficient pressure to insure that the normal limit of hyper extension has been reached beyond this no manipulation of any sort is employed. The plaster should extend up to the neck, and although it may be cut out below each axilla to allow free arm movement none must be removed from the front of the thorax (Fig 8b) It extends well over the sacrum and down to the level of the trochanters and symphysis pubis with a small area cut out over each groin to allow flexion of the hips. If the plaster cast is a good, closely fitting one it is not necessary even in lumbar fractures to

include either hip and we strongly deprecate the suggestion that these patients should remain recumbent in a plaster bed or frame.

As soon as the plaster is dry the patient is encouraged to move about in bed and is turned frequently to avoid pulmonary congestion. Wasting and hypotonicity of the spinal musculature must be avoided. From the second or third day in uncomplicated cases definite exercises for the erector spinae are practiced at regular intervals The patient should lie prone and lift the head from the bed against resistance Each lower limb should be lifted with the knee straight by hyperextending the hip. These exercises involve energetic contraction of the erector spinae and despite the plaster jacket a patient can maintain a better muscular tone in this way than he could if any amount of massage and electrical treatment were possible

After 10 days the patient may get up and walk for increasing intervals. We regard this as a very necessary part of the treatment not only because it still further assists in maintaining muscular tone and establishes the free circulation which is essential for rapid union, but because it restores the patient's mentality to normal. The sooner a man is dispossessed of the notion that his back is broken and that he "will never walk again," the more certainly is subsequent functional disturbance avoided.

Protection of the vertebrae is necessary for four months. If exercises are being constantly practiced the plaster should be retained for the whole of this time. After 16 weeks, movements of the spine itself are practiced and, if a normal musculature and a normal circulation have been maintained, there will be no difficulty in restoring full movement Manipulation to break down intermuscular adhesions will not as a rule be necessary Within six months the patient should be capable of resuming his normal occupation

While as yet I have not had the opportunity of trying this method, it sounds simple, safe, and very rational

Hempel's Method.—Other authors have described methods of treatment which combine exercise and massage with the active treatment of the fracture Hempel [*] for instance believes that he has found a way of overcoming the objections against other methods of treatment hitherto employed When there is no injury of the spinal cord the patient is laid on a hard smooth mattress at first lying on his back, and after a few days on his stomach so that he can prop himself on his elbows To make certain that sinking of the mattress cannot take place, boards are placed between it and the bed springs. As soon as the pain caused by the fracture has ceased the back muscles are massaged (*the patient lying on his stomach*) *and after seven weeks the patient is permitted to crawl on all fours as a regulated form of exercise* Having become proficient in this exercise the patient is next permitted to stand and lastly to sit. The object of the treatment is to secure perfect anatomic and functional restoration of the spinal column without injuring the spinal cord

Mock's Method.—By the methods which I have used in treating these compression fractures the marked restoration of the deformed vertebral body that has been pictured by other methods has not always

FIG. 8b.—Example of plaster cast applied with back in hyperextension and used for ambulatory treatment of fractured spines.

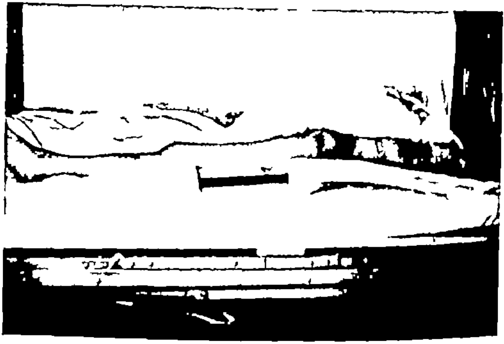

Fig. 9a.—Compression fracture of 1st lumbar vertebra. Patient in hyperextension position on a Bradford frame.

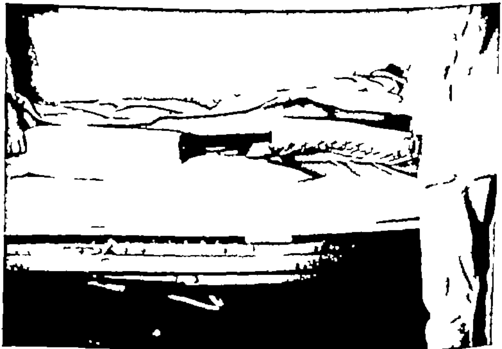

Fig. 9b.—Same case showing method of lifting Bradford frame and slowly turning patient from the frame on t his abdomen on a cart at the side of the bed. This can be done after the third week.

been secured yet the functional results have in the majority of cases been very good. Various methods are used depending upon the given case thus

Rest in bed with traction to head and lower extremities or traction and countertraction by elevating one end of the bed. A sand bag or firm pillow is placed under the back at the point of fracture to secure hyperextension

Rest in bed with hyperextension only In either of these methods the rest in bed persists for 8 to 12 weeks depending upon the extent of the injury

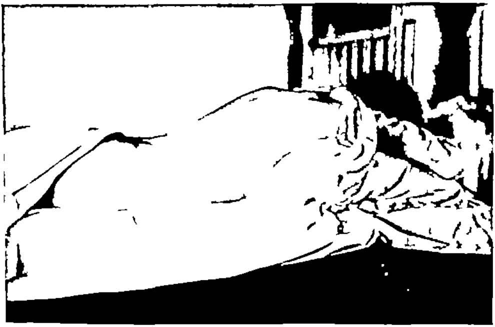

FIG. 9C.—Same patient turned from Bradf rd frame on to a cart. Note the hyper extension f this spine maintained by pillows placed on the cart and holding chest in raised position This transfer to the cart is performed daily fo the purpose of gi ing massage t the back muscles.

Usually a Bradford frame is employed It is bent in the region of the fracture so as to give a marked convexity to the firm canvas bed thereby providing the desired hyperextension The frame can be provided with a removable strip of canvas at the buttocks to facilitate the use of the bed pan The patient is firmly attached to the Bradford frame by wide flannel binders Thus by turning the frame from side to side the position of the patient can be changed while he maintains his hyperextension and thus the feared pulmonary complications are prevented After four weeks the patient can be turned completely over on the frame to lie prone upon the mattress The mattress has suffi cient pillows to raise the upper portion of the chest, thereby maintain

ing the hyperextension In this position the patient can be taught exercises, such as pushing his chest backward by supporting himself upon his arms, the amount of hyperextension being thereby increased. If the bed has been sufficiently padded and adjusted with pillows, the Bradford frame can be removed and massage can be given to the back muscles This procedure can be repeated daily after four weeks, and the amount of hyperextension exercise and the strength of the massage can be increased daily The frame is then reapplied and the patient is turned back into a recumbent position.

Almost from the beginning of this treatment, massage of the extremities, abdomen and chest, and supervised exercises of the upper and lower extremities can be instituted The technician can even massage a considerable portion of the back without unduly disturbing the hyperextension position of the patient by sliding her hands one on either side, between the patient's back and the canvas bed of the frame. After four weeks, the amount of massage and exercise can be increased, as described above After six to eight weeks, the patient can usually be lifted from the frame on to a properly padded mattress. It is well to prevent this mattress from sagging in the middle by placing boards across the bed under the springs At this stage the patient should be taught to turn over in the prone position and with pillows under his upper chest, to exercise by raising himself on his elbows or arms and again by hyperextending his thighs These exercises will maintain and increase the amount of hyperextension of the spine. After eight to ten weeks the patient can be allowed to sit up in bed for short periods and to exercise by bending forward gradually instituting the flexion exercises. These should be carefully supervised at first, and should follow the massage treatment (Figs 9a, 9b, 9c)

In from 10 to 12 weeks the patient can usually be around in a wheel chair with weight bearing starting at the end of 12 weeks, provided symptoms of pain and signs of muscle spasm and sensitive nodes have disappeared Seldom and now practically never is a belt or back brace applied to these patients For another four to eight weeks these patients are carefully supervised massage and exercise are persisted in and home work is started By the end of six months, the majority of these cases can be back at their employment, even at heavy work.

This treatment is based upon maintaining as large an amount of function in the joints and musculature of the back as possible without further compression of the fractured vertebra, with as great a restoration as possible of the form of the vertebra, and with firm union of the fracture before weight bearing is allowed The prevention of thickening and foreshortening of the ligaments contraction of the aponeurosis and adhesions and fibrotic changes in the muscles due to atrophy from disuse is held of equal importance to preventing further compression and to securing good healing of the fracture A certain amount of these changes is bound to occur therefore the persistence in the massage and exercise until all such changes are overcome is

extremely important It is very easy for such a patient to begin to hold the back muscles more or less rigid to develop faulty posture and otherwise to undo the early efforts if supervision stops too soon. Heat of course is an excellent adjunct to the massage and should precede it. Hydrotherapy in the form of hot tub baths is also efficacious before the massage

All fractured vertebrae do not fall into the class of the cases just described Some of them seem to recover completely without any treatment while others continue to have symptoms in spite of the most careful supervision The surgeon must use his judgment in the handling of each individual and will find that many will respond to the treatment even more rapidly than those just described Again consideration must be given to the forms of treatment now being advocated by many which allow earlier ambulatory care

Cervical Fractures —Fractures in the cervical region usually need immobilization for a period of six or eight weeks This can be accomplished by rest in bed with a jury mast traction apparatus by cast or by specially made neck braces with head support. A combination of traction with the neck brace is most often used Frequently these braces or a cast is worn for six months

Massage which is gentle at first, but which is gradually increased in force should be started within the first week while the patient is still in bed and in traction. The massage should include the neck shoulder and arm muscles I am opposed to a cast because it prevents massage and later exercise A brace can be removed and massage given The patient should be placed in bed or on a table and immobilization maintained by sand bags placed on either side of the head during the treatment and then the brace should be replaced This should be done every day or at least every other day After four weeks very slight active exercise such as gently turning the head from side to side and assisted active exercise such as helping the patient to lift his head slightly from the table, should be instituted After eight weeks provided the x ray shows no contraindication, the brace can be removed for longer periods each day and the amount of exercise and massage increased rapidly By the end of 10 to 12 weeks most of the average cases of fracture of cervical vertebrae without cord symptoms should be free of all immobilization and all braces and should have full function in the neck

I have seen patients with cervical fracture still wearing a brace after six months with stiff neck due to ligament and muscle contraction who have been told that they must wear the brace for at least a year Unquestionably more attention paid to maintaining function in the soft tissues of the neck and more faith in the ability of these fractured vertebrae to heal would obviate the necessity often born of fear of disaster of wearing these casts or braces for even six months let alone a year

DISLOCATIONS AND SUBLUXATIONS

Dislocations or subluxations of vertebrae require careful manipulation to reduce the luxation or subluxation If it is in the cervical region, the treatment is usually done under anesthesia. The patient's head and neck protrude over the head of the table and rest in the operator's hands Then by a combination of traction, gentle but gradual flexion of the neck, increased traction and of bringing the head backward with the neck in hyperextension, the dislocation is overcome. Pressure with the fingers just below or above the site of dislocation is firmly made to act as a fulcrum. In addition lateral movement of the head, bring ing marked lateral flexion of the neck first on one side then on the other is sometimes necessary Of course, all manipulation in the neck should be entered into with great caution lest the dislocated vertebrae should be forced into greater deformity and cause compression of the cord.

Rest in bed with early massage should start almost at once, and exercise can start after two weeks A brace may be worn for four weeks if the dislocation has been completely reduced or possibly for eight weeks if it has been incompletely reduced Here again the prolonged wearing of a brace or cast is unnecessary

Some of these cases can be reduced by applying heavy traction to the head. However, if this fails by the end of the first week, manipulation is indicated

Luxations and subluxations in the dorsal and lumbar region are extremely difficult to reduce by manipulation Usually hyperextension of the back combined with traction will result in sufficiently good reduction to obtain a good functional result. However it is in this type of case that the patient often complains of pain and weakness in the back for months and years These results occur too often and the symptoms in the different cases are too similar for them to be classed as neuroses This is the type of case in which ankylosing operations will often give the best results.

FRACTURE DISLOCATIONS

Fracture-dislocations are more frequent than pure dislocations. They must be handled as described for pure fractures In selected cases, especially in the cervical vertebrae manipulation may be resorted to in order to overcome the dislocation In other cases operation seems advisable If the attempt to reduce the dislocation fails, a bone graft operation should be performed to prevent further dislocation and damage to the cord I have seen only one case where this procedure seemed advisable and necessary

In these cases the same effort should be put forth as early as possible to give heat, massage and exercise in order to maintain function and to prevent the dire results of prolonged immobilization of joints

FRACTURES OF TRANSVERSE PROCESSES

Fractures of the transverse processes are peculiar in their behavior As a rule they result in immediate disability with pain muscle spasm and tenderness even more marked than in many of the cases of com pression fracture and these symptoms and signs will continue unduly long in spite of treatment Again the signs and symptoms will dis appear after a week in bed with heat applied to the back and the patient will begin to insist upon getting up The physician will catch him sitting up in bed in spite of his warnings and advice I have seen

Fig. —Comminuted fracture of left transverse process of 4th lumbar vertebra.

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prevent thickening and contraction of the aponeurosis Daily exercises of the legs and arms active in character are supervised by the technician. By the end of the sixth week assisted active exercises of the back are started such as hyperflexing the spine by the patient s lying prone and raising himself on his elbows or hands later by his lying on his back and lifting his buttocks from the bed and finally by his sitting up in bed first assisted and later unassisted By the end of eight weeks unless the x ray shows definite contraindications the average case will have recovered and will need no further physical therapy

FRACTURES OF SPINOUS PROCESSES

Fractures of the spinous processes are treated approximately in the same manner as fractures of the transverse processes

FRACTURES OF LAMINAE AND ARCHES

Fractures of the laminae are treated when diagnosed as described for compression fractures Chandler of Chicago has described obscure often undiagnosed fractures of the lumbar laminae which cause prolonged symptoms and which require bone transplants and fixation He has done exhaustive work on the subject. Following the operation of course there is rest in bed. I would add to this treatment measures of heat, massage and graduated exercises (Fig 11)

SPRAINS OF BACK

Etiology —Sprains of the back follow many accidents which are sufficiently serious to give a fracture but following which x ray evidence of fracture is lacking. Sudden twists or falls when in a strained position for example slipping while straining to lift a heavy object or having a sudden weight thrown upon the straining body will also often result in sprains of the back As in any other part of the body a sprain will cause a certain amount of tearing of the ligaments and attachments about the part ecchymosis or minute hemorrhages exudation and swelling

Symptoms.—The pain is usually immediate causing the patient to stop work and rest, but after a few hours it may subside and he may return to work. The next morning or a day or two later he is so sore and the pain is so marked that he cannot get out of bed or he cannot straighten up The continued use of the back has aggravated the condition.

Diagnosis.—It is extremely important to diagnose a sprain early and to put such a patient to bed at absolute rest. Heat moist or dry should be applied at once If available diathermy is a valuable means

such patients up and around and apparently well at the end of six weeks even when the x ray has shown three transverse processes, fractured, displaced slightly, and still ununited (Fig 10)

Other cases which seem to be making satisfactory progress begin to grow worse and develop into the typical chronic back cases. Too often this change dates from the time the patient is told by another doctor, the interne, the nurse, a fellow patient, or some lawyer or member of the family seeking to magnify the importance of the case, that he has a "broken back"

The term "broken back' is a potential trouble maker It brings fear and apprehension to the patient. It recalls cases heard of in the past in which the individuals never walked again It carries ideas of grandeur due to the old days of frequent lawsuits when a "broken back' was usually good for a $10,000 or $25,000 damage.

I am not in favor of withholding from any patient the diagnosis of fracture but if it was ever justified it would be in these back fractures especially of a transverse process To prevent the above dangers of apprehension from being born in these cases I usually take time to draw a picture of a segment of the spinal column show this to the patient, and explain to him how this little transverse process is broken, but that it has no connection with the so-called broken back, that it cannot possibly affect the cord and that there are so many other transverse processes to take up its function that no great damage can come from it I then explain that he must keep quiet for six to eight weeks in order to allow the fracture to unite, pointing out that often the union is only fibrous but that fibrous union will be sufficient to give him full and good function of his back once more. In spite of all these precautions, cases of fracture of the transverse process can become exceedingly difficult to treat.

Treatment.—Personally I prefer to treat these cases by rest in bed for six to eight weeks The mattress is prevented from sagging by placing boards across the bed underneath the springs A soft pillow in the small of the back will help maintain the normal lordosis

Heat should be applied at once in the form of large moist hot fomentations with large folds of flannel as the agent, the flannel being held in place by a covering of rubber sheeting A binder is then applied. The applications should be frequently changed and kept very warm Hot water bottles an electric pad or an ordinary electric light bulb and reflector may furnish the source of heat As soon as the patient can be turned over on his stomach (he should lie relaxed and let the nurse and technician turn him over) gentle stroking massage is started At first this is a sedative massage which tends to relax the spasm in the muscles and to relieve the pain. Later, the massage is increased and becomes both stroking and, by the fourth week kneading or rotary in character Its purpose now is to increase circulation to these parts to overcome any muscular atrophy, and to

prolong the condition Allowing them to remain recumbent for three or four weeks without massage or exercise is only to foster adhesions painful joints and a string of indefinite sequelae that usually eventually lead to an erroneous diagnosis of neurosis Strapping the back with firm adhesive plaster and allowing the patient to go about is better than the last mentioned procedure provided that the strapping is not too prolonged and that the patient does not develop faulty posture habits Rest heat and massage for the first week with strapping for the second week followed by systematic efforts to develop exercise and function will relieve the majority of these cases within three to four weeks However the strapping usually causes pimples and irritation and prevents proper massage If possible it should be avoided Certainly tight strapping or the early and prolonged use of a brace is often another means of causing muscle atrophy contraction of ligaments and adhesions

The commonest location for these sprains is in the low back usually a lumbosacral or a sacro-iliac condition The sprain in these regions is too often not sufficiently serious to cause the physician great concern or to justify the patient s going to bed and being fussed with As a result inadequate early treatment prolongs the condition *allows it to become aggravated or results in sequelae which are far* more difficult to relieve The latter will be considered under post traumatic conditions

Rest, heat, massage and graduated exercise are indicated and should start early whenever the history and findings suggest the possibility of a lumbosacral or sacro-iliac sprain As a rule I never strap these patients except possibly for two days to a week when they first get out of bed In a limited number of cases a sacro-iliac belt may be indicated but placing a sacro-iliac belt on a patient and telling him to wear it indefinitely without daily removal for massage tends only to doom him to invalidism Four to six weeks should be the limit for the wearing of such a belt The belt soothes both the patient and the physician often preventing the early discovery of sequelae that *must be treated and removed if full recovery is to follow A good plan* to follow when these patients first get out of bed is firmly to belt the sacro-iliac region by applying an ordinary strap belt just outside the underclothes and passing it around the body just below the antero-superior spines of the ilium The patient is instructed to remove this for rest periods and for certain exercises He seldom becomes wedded to such a belt as he does to the more elaborate sacro-iliac braces Again let me repeat that the latter have their place but only in a limited number of cases and for a limited length of time.

Some patients will not respond to the above treatment nor to any other form of treatment Certain of these either are operated on for a fixation of the sacro-iliac joint or become permanent wearers of the sacro-iliac or other form of brace When I am forced to yield to one

of applying heat and gives the quickest relief from pain Early massage, rhythmic and applied gently at first but gradually increased in force and carried always in the same direction i e. upward and outward will soon reduce the exudation and swelling As soon as the pain is relieved or after one week active assisted and active exercises should start to prevent contraction of the ligaments thickening of the aponeurosis and adhesions about the joints.

Treatment.—Allowing these patients to be up and around and to assume faulty postures in order to relieve their discomfort is only to

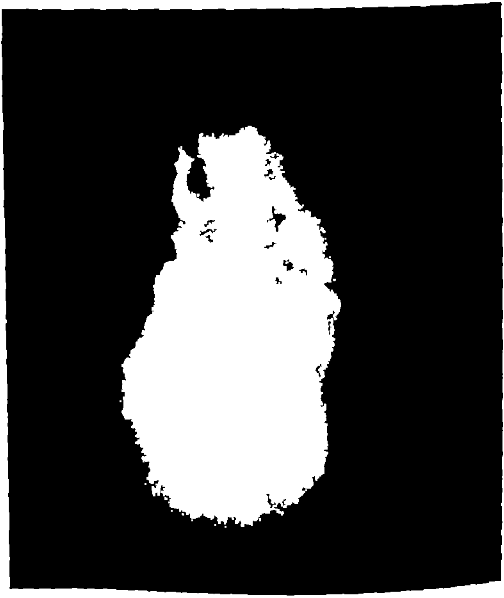

Fig. 11—Example of fracture of the lamina of the 5th lumbar vertebra. There is also a slight spondylolisthesis.

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or the other of these plans, I feel that in some way my ideals of treat ment have miscarried or have been cheated

Strains of Back

Strains of back usually occur from less severe injuries than those which result in sprains In strains the signs and symptoms are not as severe as they are in sprains. Failure, however, on the part of the physician or patient to recognize these strains and to treat them as potential trouble makers often results in prolonged disability

They can usually be treated as ambulatory cases but if the signs and symptoms begin to grow worse or are prolonged for more than a week, I favor putting the patient at absolute rest and treating him as described for sprains The ambulatory treatment consists of applying a firm binder and having the patient report daily for heat, massage and graduated active exercises The patient is instructed to take one or two hot baths a day at home in between treatments. I have seen a patient with simple strain who reported to the physical therapy labora tory for treatment grow markedly worse after the treatment. This usually occurs in the winter He is baked and massaged in the warm office, goes out into the cold rides home on a cold street car and that night develops a severe attack of lumbago or myositis. Physicians should recognize this danger and if the patient complains of "catching cold after office treatment, some form of home treatment should be substituted A baker to use in the home can be made or bought very reasonably or the physician can rent or lend one to the patient. The technician can report to the home daily to give the heat and massage. Unquestionably more attention must be paid to the effect upon the patient of ambulatory physical therapy than has been done in the past.

Lumbago Myositis Myofascitis

Lumbago myositis and myofascitis are all terms used to denote an acute painful back. The attack usually comes on suddenly and often after some minor injury or more often after some unusual strain, such as overlifting or after a change from a rather sedentary occupa tion to very active or heavy work.

This Thanksgiving at a family reunion I played a strenuous game of old-fashioned shinny with a number of my male relatives. Several of our sons were college boys and while the old guard won the game yet we were hard pressed It was a moderately cold day We became very warm and then cooled off rapidly Within two hours I had a severe lumbago It persisted untreated for two days and then disap peared Was this due to strain, to the rapid heating and cooling of my body or to a focal infection? I have no other evidence of a focal infection

We undoubtedly have traumatic lumbago and lumbago due to infec

tion Search should be made for the infection in all cases of persistent or recurring back pain. The rapidity with which a lumbago will disappear after an abscessed tooth has been pulled has been noted many times However all painful backs have not yielded to the loss of a tooth or even of all the teeth Other causes must be searched for before too many teeth, tonsils gallbladders etc. are sacrificed

The treatment of these strain lumbagos when they persist is rest heat, massage and graduated exercises Often they will yield best to infra red baking The ordinary electric glow for heating a bathroom is one of the best infra red bakers that can be secured

Locking of Vertebral Joints

Acute locking of some of the vertebral joints possibly a ligamentous dysfunction rather than a slipping or slight dislocation occurs The condition is most common in the cervical region and in the neighborhood of the twelfth dorsal and first lumbar vertebrae. It is a peculiar phenomenon and often manifests itself in the cervical region by a sense of sudden pain followed at once by a burning sensation in the neck, and later by a momentary or temporary stiffness then it subsides. Occasionally it will be more severe will persist and will require treatment In a recent newspaper the case of a woman who dislocated her neck by suddenly turning her head was described From the description of the case I believe it was one of acute locking A year ago my son grabbed his sister playfully about the neck and bent her backward. She cried out held her hand to the back of her neck and could not move her head which was held in a fixed slightly turned position I was home at the time and immediately went to her assistance. The head was fixed evidently by some locking in the region of the second to the fourth cervical vertebrae I had her sit on the floor placed a hand on either side of her head and lifted her upward allowing her body weight to be the force of traction At the same time I gently manipulated her head from side to side. There was a sensation of a sudden slip or give in her neck and she immediately exclaimed that now it was all right. Only a slight temporary soreness followed

Similar examples of locking have occurred following the hitting of a bump and then being thrown upward and backward when riding on the back seat of an automobile In one such case examined two days after the accident the patient had a painful stiff neck with very little head movement. The x ray was negative This case yielded to manipulation followed by heat and massage for three days A farmer boy was seen by me at his home in the country He had terrific pain in his back located in the region of the twelfth dorsal vertebra. His physician had given him hypodermics of morphine without any relief of the pain The condition had followed the lifting of a heavy grain sack The tenderness was marked over the twelfth dorsal vertebra and the first lumbar joint. He could not stand examination, let alone manipulation.

We were not prepared to give him an anesthetic and the family refused to allow removal to the local hospital Traction was applied to his legs, the foot of the bed was elevated, and a pillow was placed under his back He continued to suffer for almost a week, when the pain suddenly disappeared Mennell [7] describes acute locking of the costal vertebral joints and gives very well-defined methods of manipulation to overcome these Although physical therapy is seldom needed in these cases yet physical therapy and manipulative surgery are so closely related that it seems proper to mention them here.

Similar lockings may occur between two adjacent transverse processes or between an elongated spinous process and its fellow Manipulation is necessary for relief Prolonged pain following some of these cases of locking between vertebrae are undoubtedly due to a persistent synovitis Heat, massage and gradually increasing exercises are likewise indicated in these cases

Wryneck

Wryneck or stiff neck is almost as common as lumbago The ordinary case will usually disappear without treatment or with heat and massage Wryneck following injury to the cervical vertebrae or to sprains in this region often requires prolonged treatment by heat, massage and graduated exercises

Posttraumatic Sequelae

Any surgeon doing a considerable amount of reconstructive surgery will see a great number of traumatic cases weeks and months after the acute injury They are referred for treatment to overcome certain sequelae which are the result either of the injury or of the treatment given A high percentage of these cases are back injuries.

Old Fractured Vertebrae without Cord Injury

Etiology —The persistence of symptoms in cases of compression fracture of one or more vertebrae or of fractures of the transverse or spinous processes beyond a period of three months usually indicates that certain sequelae have developed which must be discovered and treated if the given part is to secure complete functional recovery The usual causes for these persistent symptoms are

A. Failure to diagnose the fracture and to institute proper treatment early Negligence in taking a lateral x ray picture is the commonest cause of diagnostic failure
B Too short a period of active treatment of the fracture
C Too prolonged a period of active treatment by a cast or other form of immobilization
D Too much dependence upon a back brace

E The surgeon s waning interest in the case after two or three months

F The development of functional neuroses

The following short résumés of cases illustrate these conditions

CASE 7 —Mr C S 35 years old was treated five months for a sacro-iliac condition. He had been kept in bed for a month, was fitted with a sacro-iliac belt, was given light treatments and was finally told to go to work He at tempted light work, but the next morning he could not stoop over to pull on his shoes. He was seen several times by his doctor but the latter had "seemed to lose interest in my case," according to the patient He was finally referred to St. Luke s hospital where he came under my care.

Examination showed a definite point of tenderness which was constantly located, at each examination directly over the fourth lumbar vertebra. Movements of the back especially when he attempted to straighten up from a stooping position caused definite rigidity or muscle spasm in the erector spinae muscles of this region From the history of the case and from these findings a diagnosis of probable fracture of the fourth lumbar vertebra was made and the x ray was then ordered The lateral view showed that a small wedge of the body of the fourth lumbar vertebra was broken off and displaced anteriorly There was a slight depression of the anterosuperior border of the body of the fourth lumbar vertebra The anteroposterior view failed to show any evidence of this injury

The case was reported as one of fracture The original doctor was asked to mail in his x rays so that we could see if this was present at the time of the original injury His x rays had been made only in the anteroposterior view My x rays and the original x rays were then submitted to another roentgen ologist, who called the condition an osteo-arthritis. They were then submitted to Dr Hollis Potter who said that the condition was a fracture and pointed out that osteo-arthritis must always involve the articular surface which was not affected in this case (Figs. 12a, 12b)

The patient's pain and muscle spasm were due to the prolonged immobili zation of the back muscles and joints by the sacro-iliac brace to holding them stiff because movement caused pain and to periods of attempting active exercise and work before he was ready for them. Certainly there was no surgical treatment indicated to remove or replace this wedge. Further immobilization offered neither temporary nor ultimate relief of the situation

The treatment instituted was first to explain the condition to the patient in common sense terms and to secure his coöperation. Then he was put to bed, and the back baked and hot fomentations applied alternately every two hours Massage once a day was started immediately Simple very graduated exercises were given at each period of massage. Whenever pain or muscle spasm appeared, the exercises were stopped and were not carried to that point again for three days. After two weeks he was allowed to go to the physical therapy department in a wheel chair for the same treatment After another week he was allowed to walk about and to go to the occupational therapy department for light work He was discharged at the end of eight weeks cured not of a broken back (for this fracture had healed albeit with slight deformity long before I saw the case) but of the soft tissue ankylosis which had developed from prolonged immobilization and disuse and which caused

muscle spasm and pain whenever undue stress was applied to these back joints.

CASE 8.—Mr O S, aged 57 a railroad engineer, suffered a compression fracture of the third and fourth lumbar vertebrae. He weighed 200 lb. He was kept at rest in bed for six months and was then fitted with a back brace. He had not been able to return to work. He was referred to me to ascertain if anything further could be done or if this man should be pensioned.

Examination revealed a very heavy short man who weighed 240 lb having gained 40 lb during course of rest and treatment His back was held rigid in a leather and steel back brace. The muscles were slightly rigid on

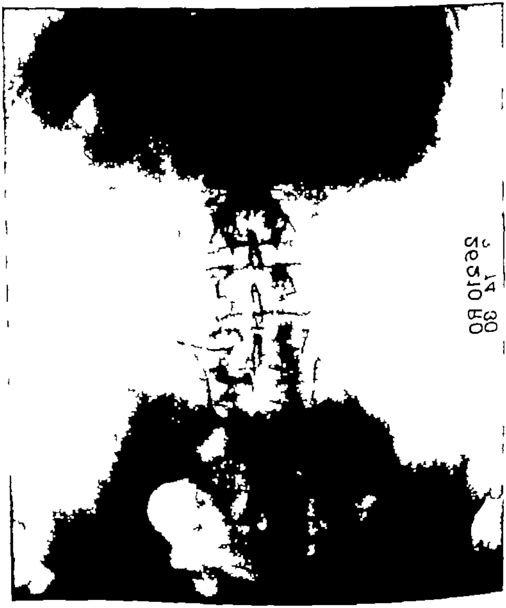

FIG. 12.—A t roposterior view f Case 7 failed to show any evidence of fracture

motion but there was no muscle spasm. The patient's chief complaint was pain and weakness in his back when he attempted to go without his brace. In addition he had swelling of the ankles which had developed since he was allowed out of bed and he had flatfeet. His basal metabolism was normal.

Fig. 3b.—Lateral view of Case 7 showing definite compression fracture with displacement of the fragment in the 4th lumbar vertebra.

Physical therapy a reducing diet, foot exercises, and gradually giving up his back brace resulted in improvement in the back muscles, the disappearance of the swelling in the lower legs, and the loss of 20 lb in weight. At the end of six weeks he was going about constantly without his brace and without complaints He was allowed to go to his home in Ohio. In four weeks he returned to us with the ankles again swollen and wearing the brace He refused to stay for further treatment and has since been retired on a pension.

The broken back of course was the exciting cause but his great gain in weight his becoming wedded to a back brace with its accompanying weakening of the back muscles and stiffening of the back joints, combined with a spirit of giving up and accepting a pension, were the real causes of this man's disability All these could have been prevented and overcome if he had been willing to put up a fight.

CASE 9 —A. R. who was injured in an automobile accident in Michigan was taken to a hospital and an x ray (anteroposterior view only) was made of his back. No fracture was found. He was kept in bed for two weeks with a diagnosis of a contused back and was then discharged He returned to his home in Chicago and was under the care of an osteopath for two weeks. Then he consulted a lawyer and started suit against the owner of the automobile. His lawyer referred him to a doctor who x rayed his back and in the lateral view discovered a compression fracture of the first lumbar vertebra. (See Figs. 4a, 4b) He reported to this doctor daily for light treatments. No massage was given At the end of 10 weeks the insurance company involved referred the patient to me with the consent of his lawyer for examination. I found the evidence of the 10-weeks old compression fracture which had practically gone untreated The patient had muscle spasm and pain on attempting any undue flexion movements of his back. The pain and muscle spasm, however caused the patient to hold his back quite rigid As has been frequently noted, this protective immobilization of the spine can cause partial ankylosis by contraction changes in the soft tissues about the spinal joints.

The patient was more anxious to secure a good recovery from his fractured back than to secure a large settlement. He agreed to take treatment and was very coöperative. He was referred to our physical therapy department for daily treatment consisting of baking the back (heat) massage, and graduated exercises I could see no reason to treat the fractured vertebra after 10 weeks by putting the patient to bed or by applying a back brace. These would only have added to the stiffening process which had already begun in his back At the end of a month his case was settled for a small amount and he returned to his regular employment of traveling salesman.

The above cases illustrate that it is not the fractured vertebra *per se* that gives the prolonged disability in back fractures but the often obvious at other times obscure sequelae that follow in the wake of such fractures

Treatment.—All during the active treatment every effort should be made to keep up muscle tone normal body functions, and a good mental attitude As soon as such treatment is safe exercises should be added to prevent loss of joint function. Then as the case becomes

ambulatory belts or braces that may undo all these efforts should be avoided as far as possible if they are applied the period of wearing them should be limited to only a few weeks Start more active heat massage exercise and occupational therapy as soon as the case is ambulatory and persist in these until full function and working ability are regained Do not allow your interest in the case to wane until the patient has recovered There will really be no need of a convalescent period after treatment has stopped if this program is carried out

Recently I examined a girl with a compression fracture of the second lumbar vertebra. She was being treated admirably Her doctor remarked that one of the nurses in this hospital had suffered a fracture of her first lumbar vertebra six months ago and that now she was doing full duty A little later he sent for this nurse She was a healthy very cheerful girl standing very erect and in response to the doctor's question Are you wearing your back brace? she replied 'Oh yes I couldn't do without it

On further questioning the nurse gave the following information

"I was in bed seven weeks and then they put on this brace and I was able to be up and around and went back to duty at the end of three months Yes I leave the brace off at night and try for a few hours once a week to get along without it, but I soon get so tired and my back is so weak and sore that I am glad to put it back on.

'Oh I feel so good and am held up so straight by this brace that I don t mind wearing it at all

This nurse was becoming wedded to her back brace. Her doctor agreed with this and was deeply interested in my suggestions This hospital has an excellent physical therapy department, and yet this nurse had never been given massage and back exercises. I suggested that these should be started and that each day she should go an hour longer without her brace As the strength and function of the erector spinae muscles returned she should be able to leave off the brace altogether probably at the end of three weeks She had been told to wear the brace for a year At the end of that time some such a program would be necessary anyway Her fracture was long since healed Why continue to wear the brace for a year and make it even harder to go without it at the end of that time? Ask any lady who used to wear a corset constantly how it made her feel at first to do without it

Old Sprains of the Back

The majority of these sprains which have symptoms persisting far beyond the period when recovery should have occurred are located in the lumbar region of the back—usually in the lower lumbar and in the vicinity of the sacro-iliac joints.

Symptoms.—Sprains in the cervical region usually manifest themselves by varying degrees of wryneck and yield more readily to heat

and massage, even the massage the patient gives his own neck muscles. Occasionally one will see persistent symptoms from such sprains where some form of neck brace or collar has been used for immobilization for any considerable period Such conditions will yield to heat, massage and graduated exercises Sprains in the dorsal region are uncommon. Here, again, persistence of symptoms too often is the result of prolonged immobilization. Therefore attention must be directed chiefly to these old persistent sprains in the lower lumbar region.

Etiology —They are usually due to inadequate treatment during the acute condition wherein the patient is allowed to remain ambulatory but, because of the pain on movement, he holds his back quite rigid—a condition of self protecting immobilization. One sees a similar condition in bursitis or other acute affections about the shoulder joint when the patient, for the purpose of relief or protection from pain, carries the arm adducted to the side of his body After a few weeks it becomes more or less fixed in this position.

Another cause for these old sprain cases in the back is too prolonged an immobilization by treatment. The patient is kept in bed, without any effort at physical therapy for three or four weeks then, because he still has pain a brace or a wide belt is applied which continues the immobilization Effort to use these back joints causes the same pain and discomfort that occur in any other part which is unduly immobilized

Pathology —There are signs and symptoms described to differentiate between a sacro-iliac and a lumbosacral sprain but these are not always conclusive. The pathology in either case is the same viz., contraction and thickening of the joint capsule, thickening of the aponeurosis foreshortening and contracture of muscles due to their being held in the position of greatest comfort and adhesions which have formed at the site of the exudate and the slight hemorrhage which accompanied the original sprain When one visualizes the sprains in back joints just as he does the common ankle sprain he then better understands the possibilities.

Diagnosis.—These cases are often extremely difficult to diagnose. Many of them have developed neuroses— 'misunderstood neuroses," I call them. The patient s suffering is misunderstood by the doctor and the family who often make the patient feel that there is not much wrong with him The patient soon develops an attitude of being misunderstood. He will not talk of his condition except with sympathetic friends and he soon begins to search for sympathetic listeners until he gets the habit of talking about his ailment. The patient cannot explain the peculiar spasm in his back on certain movements, his doctor cannot find a cause for it he develops secret fears and worries and he unconsciously begins to exaggerate his complaints and to magnify

certain signs when being examined He cannot understand why his trouble persists why he cannot be relieved why his doctor cannot find a cause In short a chain of misunderstanding develops which leads to this rather frequent development of neurosis in back cases

A pure back neurosis is not common Underneath the nervous phenomena are usually one or more organic conditions in the back which when discovered and relieved cause the neurosis to fade away

The x ray is usually of no avail in the diagnosis of these old sprains.

The ordinary physical findings may be of little help Usually how ever a systematic, careful routine examination of all the back hip and leg movements will show that certain ones of these are restricted or are causing more pain than other movements Occasionally there are symptoms of a sciatica.

Sciatica

Sciatica, if of several weeks standing will show the distribution of pain somewhere along its course tenderness on palpation over the course of the nerve atrophy most often in the thigh, and a weakened or absent Achilles reflex. Such findings are always suggestive of definite organic changes in the lumbar region

Finally I often resort to examination of these patients under anesthesia in order to prove positively where and to what extent motion is restricted

Case 10—Mr W came to me with a history of back disability of five months standing He was leaning over to his right lifting a 25 lb battery with his left hand when his left foot slipped from under him, throwing him in a side twisting movement to the left. He was in severe pain for a time, then it eased and he continued to work for the next four days. Each day his back pained him a little more and he was a little stiffer on arising each morning On the fifth morning he tried to arise and could not move unassisted His wife helped him from bed and he managed to dress. When he leaned over to pull on his shoe a spasm of pain attacked his back and he could not straighten up He was finally helped back to bed and the doctor was called who had him taken to a hospital An x-ray examination was made but it showed no fracture. He remained in bed for four weeks and then was allowed to go home Pain was still present and therefore a wide canvas back brace with steel supports was made and he wore this constantly until he reported to me four months later For weeks this patient reported to his doctor's office where light treatments were given to the back. He was thoroughly tanned over the back and left thigh. At the end of two months he had developed pain down the left thigh and leg This became so bad that he could not walk. Neither could he sit on a chair for more than 10 min without shifting all his weight to his right buttock He was miserable and yet he felt that folks thought he was putting a lot of it on" He said I would much rather work and make my $35.00 per week than to loaf and draw $16.00 a week—what do they think I am?" He had certain neurotic signs and symptoms—a misunderstood neurosis —and my interne after examining this patient told me that he was a neuro"

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The examination when he entered my service at St Luke's Hospital was negative except for slight restriction of motion on flexing the left thigh on the abdomen pain on forcing further flexion, and tenderness over the left sciatic nerve with definite muscle atrophy in both the left thigh and calf and absence of the Achilles tendon reflex The patient localized the pain each time in the neighborhood of the left articulation of the fourth and fifth lumbar vertebrae and from there down to the ilium near the posterosuperior spine.

This patient was given an anesthetic and examined. When both thighs were flexed upon the abdomen as far as possible, it was quite noticeable that the right thigh would flex from three to four inches nearer the abdominal wall than would the left. This was the only motion that seemed limited.

Treatment of this case consisted of the following

Manipulation—With the patient anesthetized my assistant flexed the right thigh while I flexed the left thigh as far as was possible without undue pressure. The thighs were then alternately extended and flexed, rocking the patient's buttocks off the table and each time bringing both thighs as nearly as possible into contact with the abdominal wall Soon there was a sensation of soft crepitus or of giving in the left side of the back near the fifth lumbar vertebra and ilium. With each rocking the left thigh came more into alignment with the right on complete flexion. The manipulation was continued until both thighs flexed equally

Those who observed the manipulation and felt the "giving" of the soft tissues in the small of the back agreed that we had broken up some old adhesions or had stretched thickened ligaments and muscles until the restricted flexion of the thigh had been overcome. This procedure was done gently rather than forcibly (Figs. 13a 13b)

Immediate After-care—The patient was returned to bed and large hot fomentations were applied to the back and changed every two hours At each changing the patient turned on his stomach and a large baking light was placed over his back. Thus there was no sudden cooling of the back He was encouraged to exercise his legs often and to flex them as far as possible A gentle but stimulating massage was given the same afternoon This treatment was continued all night with massage the next morning followed by assisted exercises The technician was shown the nature of these exercises which consisted of flexing both thighs upon the abdomen as far as possible with mild but steady pressure made upon the left thigh to increase its flexion range The massage included the left leg from the foot upward.

Continued Treatment—After the third day this patient was taken to the physical therapy department in a wheel chair and there the larger baker furnished heat to his back and leg for 30 minutes to one hour This was followed by approximately one hour of steady ever increasing in force massage. Assisted and active graduated exercises were then given After a week tub baths of hot water for 20 minutes followed by a brisk rub and the application of heat to the back and leg on returning to bed were added

This patient was constantly encouraged and every effort was made to overcome the attitude of being misunderstood. Occupational therapy consisting of basketry was started the first week. This had nothing to do with the back muscles but was a great mental diversion and helped materially

Fig. 13a.—Case of sciatica, left side, developing after lumbosacral sprain. Examination under anesthesia showed limitation of thigh flexion.

Fig. 13b.—Relative position of both thighs after manipulation. The limitation of flexion movement in left thigh has been overcome. (See Case 10.)

After three weeks this patient was able to sit for an hour without pain in the region of his left buttock The pain and tenderness along his sciatic nerve disappeared and he could walk about the ward for a short distance without the pain s returning At this stage he spent an hour in the occupational therapy workshop pedaling the jig saw with his feet and standing at the work bench.

At the end of five weeks the patient felt that he was so much better that he could return home and carry out the treatment there. He left against my better judgment. He returned in three weeks with the condition aggravated but not as bad as at first He has agreed to remain until cured which will take from 8 to 12 weeks He is now under his final treatment consisting of heavy exercises long walks and rather heavy work in the workshop Figures 14a and 14b show this patient exercising on a rowing machine.

This rather lengthy résumé serves to illustrate the methods of diagnosis the manipulative surgery and the physical and occupational therapy so often necessary to overcome these old persistent back sprains Each case is a problem unto itself and must often be handled in a different manner but the physical therapy maneuvers given in this case if persisted in sufficiently long will result in a cure in most cases Occasionally when progress seems to stop further study is necessary to find the cause It may be necessary to repeat the manipulation under anesthesia two or more times. Continued interest in the case and persistence in treatment are of paramount importance

Congenital Conditions

Congenital conditions associated with injury are most frequently found in the lower lumbar and sacral regions

Spondylolisthesis

Etiology —Spondylolisthesis or an anatomic slipping of one vertebra on another may be congenital or the result of trauma Great attention has been paid of recent years to the abnormally acute angle formed by the fifth lumbar and the first sacral vertebrae. At times this is so marked that all the weight of the trunk seems to rest upon the vertical sacro-iliac joints and very little support is offered between the fifth lumbar vertebra and the sacrum Usually in these cases there is a more marked lordosis in the lumbar region A condition of hyperlordosis may result in a gradual stretching of the ligaments in this region, and when some sudden torsion or rotation strain occurs as the result of a mild or severe trauma, the symptoms of a strain or sprain of the lumbosacral region develop This abnormality is often associated with faulty posture The slight lifting or the sudden turning which is blamed for the condition is usually only the 'last straw the real cause being the congenital condition the faulty position and the years and years of continued strain exerted upon this joint There is

FIG. 14a.—Mr W (Case 10) exercising on a rowing machine eight weeks after manipulation of the back for lumbosacral sprain and sciatica.

FIG 14b.—Same case as Fig. 14a exercising on rowing machine

should then be put at rest on a firm, straight bed with increasing amounts of firm pillows added to the lumbar region to preserve the benefits of the manipulation and gradually to increase the lordosis

Continuous heat, daily massage and graduated exercises should be added to the treatment of manipulation. The effort should be made to relieve the pain cure the sprain, and restore the patient to normal if possible without resorting to immobilization and support.

In older individuals the fixity of the joints and soft tissues may prevent correction and the only relief may come from back support by a suitable brace.

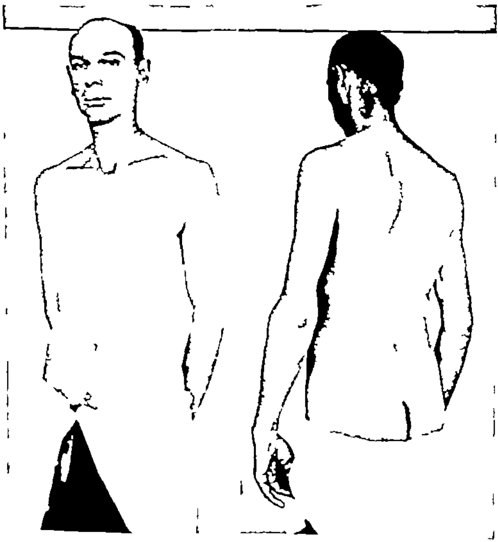

FIG. 15—Examples f patient with flat back who suffered constant low back pain until he was taught proper posture and exercises to overcome the condition

no wonder that complicated questions arise in these cases, when compensation is involved, considering the insignificance of the alleged accident as a causative factor as compared with these other conditions in no manner related to the accident

Treatment.—The treatment of such an injury should be upon the same principles as those laid down for lumbosacral sprains—rest, heat, massage, and very carefully guarded and graduated exercises. Great attention should be given to the exercises aimed at correcting faulty posture. Many of these cases are far advanced in years before the joint finally weakens and the "last straw" force lays them low Often the back pain will persist in spite of all that can be done, and relief is secured only by wearing of a suitable support. Such a support should aim at the correction or the support of the "pot belly" as well as the immobilization of the lumbosacral region

Flat Back

Flat back or a loss of the lumbar lordosis usually shows an abnormal lessening of the lumbosacral angle. The condition receives very little consideration and yet it may cause even more marked disability than the hyperlordosis Individuals suffering with it tend to suffer strains or sprains more readily The mechanism for correction is the same as for the opposite condition (Fig 15)

Diagnosis.—Patients with a flat back can usually be recognized by inspection which will reveal the characteristic flatness of this area when they lie upon a flat table, all the lumbar spinous processes rest on the table the characteristic movements of this region are lost, for example, on flexion and extension, the lumbar spines seem to move as one bone somewhat similar to a poker back, and finally these patients cannot increase the lordosis by raising their bodies from the table with the weight resting upon the shoulders and feet, with the lower legs flexed

In the absence of all other physical findings and of negative x-rays, if an individual shows these characteristic signs of flat back, one should suspect a sprain aggravated by this congenital condition.

Treatment.—In younger individuals manipulations usually repeated at intervals and if necessary given under an anesthetic, may be employed The purpose is gradually to lift upward on the lumbar vertebrae and endeavor to increase the lordosis With each manipulation the same flexion of the thighs upon the abdomen and the stretching of the back muscles ligaments and adhesions should be employed as described for manipulations in sprains of this region. The patient

should then be put at rest on a firm straight bed with increasing amounts of firm pillows added to the lumbar region to preserve the benefits of the manipulation and gradually to increase the lordosis

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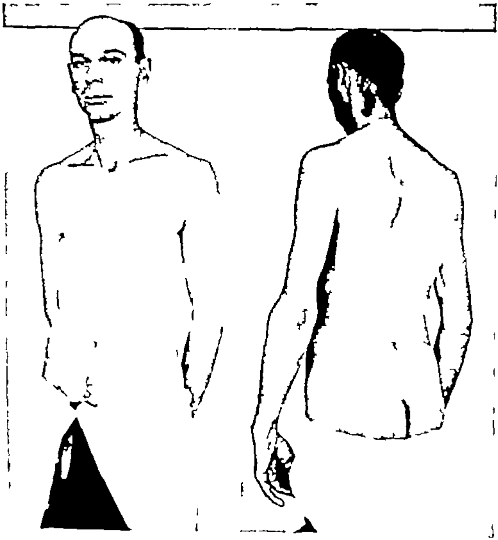

FIG. 15—Examples of patient with flat back who suffered constant low back pain until he was taught proper posture and exercises to overcome the condition

Sacralized Fifth Lumbar Vertebra

This is not an uncommon anomaly It is seen in a great number of cases x rayed for other conditions, and in the vast majority of these absolutely no symptoms of discomfort or disability can be elicited. In other cases however in which there is backache, and in which the x-ray picture shows this defect, we are probably too prone to attribute the trouble to an impinging fifth transverse process. Unquestionably there are injuries to the back in which these do play a part. There are probably other cases of low back pain not related to injury that cannot be explained upon any other basis

Pathology —This congenital condition generally shows a sacrum set low between the ilia with one or both fifth transverse processes impinging upon the sacrum. Usually one of the fifth transverse processes is widened and sometimes irregular in form and lies in close apposition to the sacrum on that side. At times a definite articulation may be seen between the two

Etiology —Injuries to this region may occur in many ways. A restriction of motion due to the enlarged process must exist with an imbalance between the two sides which conceivably could make the opposite side more prone to strain A sudden torsion or lateral flexion of the body toward the side of the anomaly could cause a bruising of the process or the sacrum, a pinching or contusion of the soft tissues lying between a traumatic arthritis if an articulation had developed between the two I am convinced that I have seen several cases in which the entire trouble was due to this congenital condition combined with an injury

Mennell [7] in a recent book entitled *Backache* describes a patient who suffered an injury to his back and in whom the x-ray findings suggested the possibility of an impinging fifth transverse process. The patient died of a pulmonary hemorrhage during the course of treatment. He describes his findings at the autopsy and his conclusions as follows

> Thanks to the courtesy of Dr Weir who performed the postmortem examination I was able to turn my attention to the lumbosacral junction. This we dissected out with care and found that certain movements of the trunk caused the thin edge of a chisel to be so firmly nipped between the tip of the elongated transverse process and the top of the sacrum that it was impossible to withdraw it without the exercise of extreme force. No false joint could be detected between this transverse process and the top of the sacrum and it at once became obvious that when this movement was performed during life the soft structures between the transverse process and the top of the sacrum must have been pinched very severely The most prominent point in the examination of this patient during life was that, in the sitting position rotation of the trunk in one direction was painless, while

rotation in the other direction greatly augmented the symptoms of which he was complaining particularly when the trunk was inclined backward Moreover the fact was quite definitely established that only rotation in the one direction had this effect and the whole of the rest of the examination which has been previously explained, was completely negative So too on postmortem examination it was only the one movement which caused the nipping between the transverse process and the sacrum—a nipping which it was quite impossible to secure on the opposite side in any position

Of course there is always the danger of basing an opinion on the examination of any one case but when years of experience in dealing with an immense mass of material lead to entire change of opinion, and when the one case in which examination was possible entirely confirms the clinical experience on which this *volte face* was based, the value of this one case is materially enhanced. It is unlikely that an opportunity of repeating the investigation will occur and from a technical point of view the occurrence of even this one case must be regarded as a piece of extreme good fortune

The question will of course be raised how this particular patient whose life had been spent in ordinary laborious work had been able to carry on, year after year without symptoms in spite of the fact that this enlarged transverse process had undoubtedly existed throughout his working years. If we are to attribute the symptoms from which he was suffering to the presence of this transverse process there can be only one possible explanation which is as follows

The ligaments connected with the lumbosacral junction are of a complexity and a strength which can be described only as immense and it is to be presumed that these ligaments are so arranged that, in ordinary life movement to an extent which will allow the production of symptoms is prohibited Thus as long as these ligaments remain intact, unstretched and uninjured an individual can carry on free from symptoms, in spite of structural abnormality When, however as the result of accident undue strain is thrown upon these ligaments a stretching which only adds an infinitesimal amount of mobility to the joints may none the less be sufficient to allow just enough mobility of the tip of the transverse process to cause a nipping of the soft structures, and thus to produce symptoms.

The abnormality may be suspected as the cause when pure rotary movements to one side or the other increase the pain in this locality When this congenital anomaly is present, in the absence of other findings it should always be considered in the light of a causative factor The following case is illustrative

Case 11 —C F., aged 40 was thrown backward by a sudden jerk of a train and struck his back forcibly against a stove He was twisted sideways and the small of the back was bruised. He was taken to a local hospital where an x ray picture was made but he was told there were no fractures. His back was strapped and he was allowed to go home Symptoms increased and he could not move his back without excruciating pain He reported to the doctor for 'light treatment and after three weeks a strong back brace was made for him which he wore constantly sleeping in it for the first

Sacralized Fifth Lumbar Vertebra

This is not an uncommon anomaly It is seen in a great number of cases x rayed for other conditions, and in the vast majority of these absolutely no symptoms of discomfort or disability can be elicited. In other cases, however, in which there is backache, and in which the x ray picture shows this defect, we are probably too prone to attribute the trouble to an impinging fifth transverse process Unquestionably there are injuries to the back in which these do play a part. There are probably other cases of low back pain not related to injury that cannot be explained upon any other basis

Pathology —This congenital condition generally shows a sacrum set low between the ilia with one or both fifth transverse processes impinging upon the sacrum Usually one of the fifth transverse processes is widened and sometimes irregular in form and lies in close apposition to the sacrum on that side. At times a definite articulation may be seen between the two

Etiology —Injuries to this region may occur in many ways. A restriction of motion due to the enlarged process must exist with an imbalance between the two sides which conceivably could make the opposite side more prone to strain A sudden torsion or lateral flexion of the body toward the side of the anomaly could cause a bruising of the process or the sacrum a pinching or contusion of the soft tissues lying between a traumatic arthritis if an articulation had developed between the two I am convinced that I have seen several cases in which the entire trouble was due to this congenital condition combined with an injury

Mennell[1] in a recent book entitled *Backache* describes a patient who suffered an injury to his back and in whom the x-ray findings suggested the possibility of an impinging fifth transverse process. The patient died of a pulmonary hemorrhage during the course of treatment. He describes his findings at the autopsy and his conclusions as follows

Thanks to the courtesy of Dr Weir who performed the postmortem examination I was able to turn my attention to the lumbosacral junction. This we dissected out with care and found that certain movements of the trunk caused the thin edge of a chisel to be so firmly nipped between the tip of the elongated transverse process and the top of the sacrum that it was impossible to withdraw it without the exercise of extreme force. No false joint could be detected between this transverse process and the top of the sacrum and it at once became obvious that, when this movement was performed during life, the soft structures between the transverse process and the top of the sacrum must have been pinched very severely The most prominent point in the examination of this patient during life was that, in the sitting position, rotation of the trunk in one direction was painless, while

sage which was increased gradually in force After two weeks when pain had been eliminated he went to the physical therapy laboratory for the same treatment plus graduated exercises Within four weeks he was working in the occupational therapy department—work which necessitated bending to the left to pick up objects (Fig 16)

He has recovered for the time being but probably some rather trivial accident will cause another attack In these cases there are other lines of treatment which are advocated

Treatment.—Operative treatment is advocated by several good surgeons who advise the removal of the offending transverse process Some good results have been reported. On the other hand I have seen two patients who had been operated on and yet both of them had continued trouble Personally I believe operative treatment should be limited to only a very few cases these to be chosen from younger individuals who fail to react to proper physical therapy management. After operation the same physical therapy treatment must be given to insure complete recovery

Immobilization by a supporting or fixation brace to prevent the movements which cause pain may also be adopted. If the brace is to be eliminated finally most cases will need careful physical therapy management.

Spina Bifida

Spina bifida is a congenital condition quite frequently seen in x rays taken because of complaint of back pain following some injury As a rule the condition is simply noted but no connection with the injury is considered. Mennell calls attention to the fact that occasionally the upturned incomplete spinous process of a spina bifida may lie close to the adjoining vertebra and that soft tissues may be pinched between these on certain movements.

The frequency with which this condition as well as other anomalies is found in the lower back in injury cases compared with the infrequency of their findings in x rays for other conditions makes one conjecture on the probability of inherent weakness in the spine due to spina bifida as a predisposing cause to trauma

Spinous Process Anomalies

Bifurcated spinous processes may cause pain by catching a ligament or by locking on certain movements Occasionally they may be so angulated as to impinge on the adjacent spinous process Mennell again points out that this latter condition may cause a pinching of soft tissues on certain movements

The treatment recommended by Mennell for these conditions is the wearing of a belt with a plate fitted to the region of the spine to prevent overextension the movement which usually causes the pain One should consider operative removal of the offending spinous process

month. In spite of this treatment his disability continued. Whenever he left the brace off the pain and discomfort would grow worse.

He was referred to me after seven months of this continued trouble. Examination showed a muscular, well built man of some 140 lb with no extra fat. He wore a back brace and walked carefully as though protecting his back against jar He could flex forward almost normally and without complaint of pain. Extension of his back developed pain slightly above and internal to the sacro-iliac joint. Lateral flexion and rotation to the left caused definite pain The thighs could be flexed upon the abdomen equally yet extreme flexion of the left thigh gave pain. Kernig's sign was not present and there was no sciatica. Examination of the back showed no deformity Palpation with the finger tips showed a sense of tenseness or spasticity in

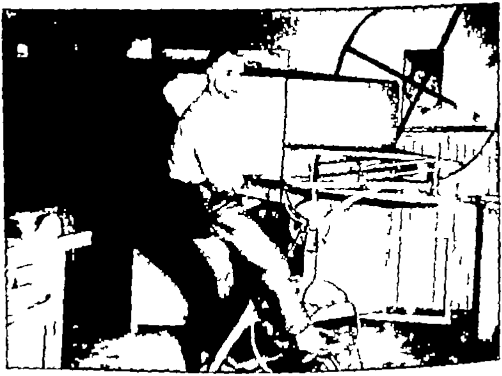

FIG. 16—Photograph of C. F (Case 11) working in the occupational therapy department using a jig saw

the muscles of the left side as compared with those of the right, and this could be increased by movements which caused pain Tender or sensitive nodes could be felt in the muscles of the left side of the low back.

The x ray showed the sacralized fifth lumbar vertebra with the greatly widened transverse process on the left as shown in Figure 2 It was possible to see a slight articulation between the process and the sacrum.

Diagnosis was a bruise of this anomalous articulation with a traumatic arthritis plus contraction of the ligaments muscles, and aponeurosis from prolonged immobilization and disuse

Treatment consisted of placing this patient in the hospital where he rested in a firm straight bed and was given continuous heat and gentle daily mas-

held firm and almost rigid knees straight and feet straight or toed in. A full length mirror should be installed in the treatment room and these patients should be drilled in front of it until they have this proper posture firmly fixed in mind. In the presence of strained or sprained back the acute condition must be relieved and graduated exercises leading up to the postural exercises should be used (Cole and Brown Vol. III)

Flatfeet

Flatfeet may be the basis of certain faulty postures or of imbalance underlying the painful back With this as a predisposing cause a slight injury may excite the back trouble.

I have had several cases of persistent disability from alleged injuries referred to me for reconstructive treatment whose condition was relieved by massage and exercise of the feet combined with rest. A very good exercise for the feet is walking on the toes in a pigeon-toed position. Flatfoot is considered at length by Lewin (Vol. II)

Osteo-arthritis

Osteo-arthritis of the spine is so frequently found associated with an injury that one s ingenuity and judgment are taxed to determine whether the injury plays a part in the trouble or whether it is solely due to the arthritis.

Etiology —Injuries to the joints of the back can produce an acute traumatic arthritis just as can injuries in other joints Repeated traumas in time may lead to a hypertrophic arthritis Probably a severe injury such as a compression fracture, may be accompanied with some definite damage to the articular surfaces, and such a joint may more readily be subject to arthritis

Unquestionably when the "spring" is gone from the feet and one becomes conscious of pounding his back joints when walking on a hard pavement, one is in a potential position to develop a type of traumatic arthritis. The repeated trauma to the back which is the result of hard work in faulty positions as in mining in time results in osteo-arthritis.

Overlifting a sudden twist, the jerk of a train a fall or a similar mild trauma in such an individual will result in a disabling back condition. The patient frequently has never been disabled and has never been conscious of the arthritis. To convince him that he has a diseased condition and that the injury played no part in it is impossible In fact one must in fairness say that in the majority of these cases the injury although trivial aggravated or excited a latent arthritis.

Treatment.—The treatment of arthritis is dealt with at length in other chapters These cases however must be put at rest during the acute stage and heat should be applied to relieve the pain. Dry heat, such as an electric pad a baker or an infra red lamp is best Traction

I have had one case of fracture of the fourth spinous process where the signs and symptoms were quite similar to a sprain fracture about other joints Rest, immobilization in a firm, straight bed, with heat, massage, and graduated exercises after four to six weeks, were the forms of treatment followed

Injuries of the Coccyx

Congenital anomalies are common in this bone. Fractures and dislocations of the coccyx are exceedingly difficult to diagnose. The x-ray of the normal coccyx in a large number of cases shows all kinds of variations in the position of the coccyx. Thus Potter states that he will seldom give an opinion relative to a dislocation of this bone. Fracture lines may occasionally be demonstrable.

The history of a fall or blow directly on the coccyx followed by acute symptoms is far more suggestive. Old cases of long standing with painful coccyx dating from such an injury often develop such rare and obscure symptoms that one is prone to say that the patients are neurasthenic.

Early manipulation of the coccyx with the index finger of one hand in the rectum and the finger of the other hand pressed against the back of the coccyx will sometimes give miraculous results

All cases of continued pain and especially pain on movement or after sitting for any length of time should receive careful physical therapy before operative removal of this bone is considered. Heat (in this case, heat in the form of diathermy) will usually relieve the pain temporarily Heat should be followed by massage. After a few treatments of this nature manipulation of the coccyx should be done to see if the painful condition cannot be permanently eliminated After several attempts have failed then the surgeon is justified in considering operative removal Physical therapy especially heat and massage, should follow the operation.

Postural Conditions Associated with Injury

Faulty posture especially the relaxed type—the head carried forward the neck markedly flexed a somewhat hollow chest a dorsal round back the 'pot belly' with relaxed abdominal muscles and a marked lordosis in the lumbar region knees slightly bent, and feet turned outward—is characteristic of weak back. When such an individual suffers even a trivial injury he develops a strained or often sprained back that is very persistent.

Any treatment of these cases that does not aim at the correction of the faulty posture is usually doomed to fail. The strain or sprain must be treated as already outlined

In addition, these patients must be drilled to hold up their heads, chin dra[illegible] lightly in, back erect, abdominal muscles sucked in and

Heat either moist or dry, and even diathermy may be used to aid in the absorption of these blood collections Later massage consisting of gentle stroking in the direction of the venous flow will be of great assistance Seldom is it necessary to incise and evacuate the large blood clot, although in certain cases this may be advisable

Burns

Burns of the back are difficult to treat because they are often accompanied by burns on the abdomen and it is hard to keep the patient off his back. It is equally hard to prevent soiling and infection in the low back burns

Tannic acid treatment may be indicated Often these cases do better under open air and light treatment. The patient is placed on his abdomen a sterile tent is made over the bed and heat is applied to the back by a large electric light bulb The temperature in the tent is maintained at 76 to 80 F (24.4 to 26 6 C) Such a patient can be lifted from the bed and suspended in a tub of warm water to soak away the crusts This form of hydrotherapy is dealt with by Blair and Brown (Vol. II) It can be repeated two to four times per day Ultraviolet treatment of the scars followed by massage is indicated if excessive scarring occurs

Sensitive Nodes

In many cases of old back injuries as well as in persistent back pain from posture disease or other cause we frequently find on careful gentle palpation small slightly movable tender nodes which seem to lie in the muscle or fascia These have been called fibrositic deposits "myofascitis and by similar descriptive names indicating that they are changes in the muscle or fascia.

For several years I have noted and have called my colleagues attention to small sensitive nodes under the skin in many of these chronic back cases A peculiar phenomenon in connection with these nodes is their tendency to disappear on persistent palpation. Thus one feels the node moves it around palpates it for a time and then it seems to disappear I have called one or two of my associates to examine such a node. Perhaps by the time the third doctor starts to feel it the node is no longer present. Technicians have noticed these 'knotted muscles" disappear under their massage A similar phenomenon is often noticed in palpating a spastic colon. After it has been rolled several times under the examining finger the bowel seems to relax and can no longer be palpated A more acute condition is seen in 'muscle cramp" when in the calf of the leg especially a hard knot excruciatingly painful appears It is often relieved only by massage or by bearing weight upon the leg when it suddenly disappears

is often a useful measure Very gentle stroking massage should be given daily Only such exercises as flexing and extending the lower legs are all these patients can stand in acute cases, but as the acuteness subsides, the force of the massage is increased, and assisted exercises such as helping the patient to lift the shoulders or placing the hand under the buttocks and having the patient contract the muscles as though lifting his back from the bed, are added. Great attention must be paid to the bed during this stage It should not sag or cause faulty posture positions to develop As soon as possible bring flexion and lateral motions and extension into the exercises and continue the heat and massage. *Diathermy* may now be found an excellent method of giving the heat. That method of applying heat which gives the greatest relief of pain is best. Many methods may have to be tried, but the treatment must be persisted in until the patient has again returned to that painless quiescent stage of arthritis which existed prior to the injury

General treatment must not be neglected Every arthritic patient has a pitcher of lemonade at his bedside and he is urged to drink at least two quarts in the 24 hours. Aspirin, sometimes combined with pyramidon, is used to relieve pain Effort must be made to build up the general condition of the patient.

A certain number of these cases will not be relieved by this régime. Immobilization of the back in a specially made back brace may be the only means of allowing such a patient to become ambulatory However, before the back is immobilized in a brace every effort should be employed to prevent the contraction and disuse of the muscles the thickening of the joint capsules and ligaments following the synovitis of the acute condition and the painful stiff back. Certain cases will gradually become quiescent in a brace and the brace can then be eliminated, but many arthritic patients who must wear a brace will be semi invalids

Tuberculosis or Malignancy

Injury may be the first indication of *tuberculosis* a malignancy (primary or usually metastatic), or other diseased condition of the spine. The treatment of these conditions is dealt with in other chapters.

Injuries to Soft Tissues of Back

Hematomas may develop in the back and may be of extremely large size and quite disabling I have seen several cases of fractures in the lumbar region and two with fractures of the pelvis develop large hematomas in the back and flank In two of these cases aspiration of the mass removed several hundred cubic centimeters of bloody serum. In one case the aspiration had to be repeated three times at intervals of two and five days.

Heat either moist or dry and even diathermy may be used to aid in the absorption of these blood collections Later massage consisting of gentle stroking in the direction of the venous flow will be of great assistance Seldom is it necessary to incise and evacuate the large blood clot, although in certain cases this may be advisable

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Etiology.—One conjectures concerning these more chronic sensitive nodes which are felt in the lower back and are often present in the muscles of the back of the neck and frequently in the lower extremities Is it not possible that they are spastic muscle bundles or muscle fibers and that all these phenomena are more or less due to the same causes? We see spastic colons in nervous, highly strung, tense individuals Often there is a history of worry phobias of various kinds, and fatigue due to all work and no play There is bowel dysfunction which may cause the local fatigue. In the acute muscle cramp fatigue is often present, and it is very common in the pregnant woman who is heavy on her feet. Hunters sometimes get it at night after a hard day's tramp in the woods Imbalance due to flatfoot or changing from high heels to low heels may cause it Frequently it is noted after long periods of stress and great fatigue

In the more chronic, localized sensitive nodes in the injured back we have the fatigue of dysfunction in the muscles the worry and nervousness over the condition the fatigue of holding the back more or less rigid and the lack of exercise, often the patient is a highly tensed individual

Usually the condition is ascribed to a toxic or infectious origin and is designated as a myofascitis It is mentioned as an indication for colonic flushing to rid the body of these toxic substances but in my opinion there is real evidence which points to the possibility that this condition is due to fatigue poisoning or the dysfunction of the local innervation to a small muscle bundle due to local or general fatigue.

Fatigue.—Fatigue is thought of in connection with hard work. "Dead tired at night from a hard day s work involving much muscular activity is a healthy condition as a rule but fatigue that comes from great tension as seen in the high-powered executive or in the tensed nervous woman worn out by the cries of the baby, the fussing of the older children and the housework or fatigue due to pain discomfort, holding one s back rigid to get a little respite from pain—all these continued over days and weeks can be a very unhealthy type of fatigue

Individuals with fatigue of this kind can develop a spastic colon or backache The colon can be palpated usually in the left lower quadrant. The sensitive nodes herein described can likewise be palpated in the case of backache Cure the one by rest and change of habits release the tension and establish healthy exercise and you usually cure the other Perhaps colonic flushings help but I have seen many cured without them by developing a health régime correcting faulty posture relieving the causes for worry at home or at work, and applying heat and massage to the sensitive area in the back of the neck or low back.

Eight years ago I developed a lame back and pain down my left sciatic nerve I was treated with intermittent heat and massage with

only temporary relief Finally I had my teeth x rayed and took the films to Dr Thomas Gilmer positive that two of my teeth had better come out. Dr Gilmer was on the same hospital staff and knew that I had been working very hard and under great tension He asked relative to my last vacation and how much exercise and play I was getting It had been a year since I had had a short vacation and I had almost for gotten how to play or exercise. Instead of pulling the teeth he gave me a valuable talk on fatigue and fatigue poisoning from prolonged high pressure work and suggested that a vacation would cure the back and leg trouble. The next week accompanied by my wife I started for Seattle The first morning we left our sleeper for 15 minutes at Minneapolis and walked up and down the platform. I felt very peppy and finally my wife asked concerning my backache To my surprise both the backache and the tendency toward sciatica had disappeared and never returned except years later when I again became tensed up with overwork. This was not neurosis—it was simply relaxation and getting rid of chronic fatigue

Let an individual prone to these sensitive nodes sustain an injury ever so trivial and frequently he develops a chronic traumatic back or let one suffer a sprained back and go for weeks with the back held rigid by a protective muscular tension or lie in bed without exercise or massage and he will develop these sensitive nodes Thus they play a very important rôle both in diagnosis and in treatment.

Diagnosis.—When located in the back of the neck they are felt just lateral to the cervical spines and are usually superficial although deep palpation may be necessary to feel them. At times they occur in the supraspinatus muscle or over the scapula. They are often mistaken for glands. They are sensitive to pressure are usually accom panied with a sense of soreness or slight stiffness in the neck and often cause a low-grade occipital headache. They usually soften and disappear under massage but may return again in a short time. A mild form is that found in tired business men who notice the tense sore feeling in the neck after going to bed and who are frequently relieved when the wife rubs the back of the neck for a short period

When these occur following injury or in cases of long illness regular periods of application of heat followed by at least 30 minutes of rhyth mic, stroking massage and then kneading massage will relieve the con dition. The treatment must be persisted in until the relief is permanent.

In the small of the back these sensitive nodes are most frequently felt in the gluteal regions just outside the sacro-iliac joints in the erector spinae muscles near their outer borders and opposite the fourth and fifth lumbar vertebrae or just lateral to the spinous process of the first lumbar vertebra. Often a sensitive area is felt near the sciatic notch and similar sensitive nodes are usually present in one or both legs The commonest site in the leg is at the upper margin of the calf about one inch from the inner side and two inches below the head of the tibia.

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Symptoms.—The signs and symptoms caused by these nodes in addition to their sensitiveness are radiating pains or more often a slight discomfort with restlessness The patient moves his legs frequently 'can t hold them still," and at night when he is falling to sleep the leg will jerk spasmodically

Treatment.—The treatment as already indicated is general and local Remove the factors of tenseness, nervousness and fatigue, and develop healthful exercises and relaxation. Improve elimination. Locally the condition must be treated by heat, massage, and graduated exercises Often diathermy is found very beneficial as it relieves the pain causes a local congestion and when followed by massage, will often cause very persistent sensitive nodes to disappear In place of massage the sinusoidal current or a strong vibrator may be used. I know many taut business men who scuffering with this condition in the neck or shoulders have their barber use a vibrator on the part. The use of a galvanic current with the needle inserted directly into the node has been advocated as well as acupuncture

Traumatic Neuroses

Definition.—A pure neurosis is one in which all the signs and symptoms are based upon a functional condition in contradistinction to those conditions with an organic background I believe it is impossible al ways to rule out the influences which certain minor organic conditions play in the neurosis This is certainly true in traumatic neuroses.

Etiology —Traumatic neuroses may develop in spite of the fact that the trauma was trivial or nil and that absolutely no demonstrable organic lesions resulted from the accident This type of neurosis is often seen in patients who were on the edge of a terrible accident but escaped without a scratch In others the organic lesions the result of an accident have been cured but a functional neurosis has developed during the period of disability and continues as the sole cause of in capacity In this latter group the cause of the neurosis may be the nature of the accident the nature of the trauma, some statement made by the attending physician which exaggerates the importance of the injury in the patient s mind statements made by the family, the nurse or often an interested lawyer which exaggerate the importance of the injury in the patient s mind or the true compensation neurosis where the desire for a good settlement causes the patient to dwell upon his injury until its importance has become magnified in his own mind. Occasionally the desire for sympathy or the desire for revenge—for example, when a patient wishes to prove some other physician wrong —and similar mental impulses are behind the neurosis Finally there is the third group in whom the physician fails to find the evidence of organic injury and yet the patient continues to have disability Always

in this group some remnant of the organic lesion is still present which forms the underlying basis of the neurosis Elsewhere in this chapter I have referred to this type as the misunderstood neurosis Diligent search on the part of the physician is necessary to reveal the under lying organic condition.

As the years go by I am positive that many of us are too prone to label our patient as a case of true neurosis when the real condition is a combination of some traumatic organic lesion with a superimposed neurosis.

Classification.—In prescribing or practicing physical therapy in functional conditions it is imperative to classify these cases in one of the following groups

GROUP I TRAUMATIC NEUROSIS NO ORGANIC INJURIES PURELY A FUNCTIONAL CONDITION —In these it is seldom wise to let the pa tient feel that he has an injury which must be treated If you dismiss such a case with the statement, There is absolutely nothing wrong with you he will usually go away disgruntled. Often instead of helping him you have made his condition worse

In cases of alleged back injury in this group one usually finds that such patients have fallen into faulty postures due to alleged pain or have become soft and flabby due to lack of work over a long period of months or have simply fallen into faulty habits of holding the back stiff walking with a limp or exhibiting organic lesions which do not exist.

As a rule it is wiser in this group to gain the patients confidence and then gradually to remove from their minds the fixed idea of organic injury—by various types of explanatory talks pointing out that instead of being scared to death by an accident that might have been ex tremely serious they were scared into a back disability At this stage one can usually tell them frankly that absolutely no organic injury re sulted from the accident but that the injury was all mental and that the long-continued disuse of the back with gradually developing faulty postures or stiffness is the sole cause of disability During this period of gaining their confidence physical therapy (which is only another name for common sense handling of the case) should be administered. It may be given by the physician or some member of the family but as a rule it can best be administered by a trained technician under the direction of the physician Physical therapy should consist of a certain amount of massage and large amounts of retraining exercises Reëducation of joint function is just as important in the numerous joints of the back as it is in the hysterical knee joint therefore all exercises should be directed toward the reeducation of these joints the obliteration of the stiff back the correction of faulty posture and functional limps and the gradual hardening of the patient

Success in curing this type of neurosis depends upon gaining the

Symptoms —The signs and symptoms caused by these nodes in addition to their sensitiveness are radiating pains or more often a slight discomfort with restlessness The patient moves his legs frequently "can't hold them still' and at night when he is falling to sleep the leg will jerk spasmodically

Treatment.—The treatment as already indicated is general and local Remove the factors of tenseness, nervousness, and fatigue and develop healthful exercises and relaxation Improve elimination. Locally the condition must be treated by heat, massage, and graduated exercises Often diathermy is found very beneficial, as it relieves the pain causes a local congestion and, when followed by massage will often cause very persistent sensitive nodes to disappear In place of massage the sinusoidal current or a strong vibrator may be used. I know many taut business men who scuffering with this condition in the neck or shoulders have their barber use a vibrator on the part. The use of a galvanic current with the needle inserted directly into the node has been advocated as well as acupuncture.

Traumatic Neuroses

Definition.—A pure neurosis is one in which all the signs and symptoms are based upon a functional condition in contradistinction to those conditions with an organic background I believe it is impossible always to rule out the influences which certain minor organic conditions play in the neurosis This is certainly true in traumatic neuroses.

Etiology —Traumatic neuroses may develop in spite of the fact that the trauma was trivial or nil and that absolutely no demonstrable organic lesions resulted from the accident This type of neurosis is often seen in patients who were on the edge of a terrible accident but escaped without a scratch. In others the organic lesions the result of an accident, have been cured but a functional neurosis has developed during the period of disability and continues as the sole cause of incapacity In this latter group the cause of the neurosis may be the nature of the accident the nature of the trauma some statement made by the attending physician which exaggerates the importance of the injury in the patient s mind statements made by the family the nurse, or often an interested lawyer which exaggerate the importance of the injury in the patient s mind or the true compensation neurosis where the desire for a good settlement causes the patient to dwell upon his injury until its importance has become magnified in his own mind. Occasionally the desire for sympathy or the desire for revenge—for example when a patient wishes to prove some other physician wrong —and similar mental impulses are behind the neurosis. Finally there is the third group in whom the physician fails to find the evidence of organic injury and yet the patient continues to have disability Always

When the cases in this group are due to exaggerated statements by the relatives or by some interested lawyer one must make sure that the desire for recovery is greater than the desire for compensation If the former is the case the patient should be handled as just described However if the desire for compensation sympathy or revenge is the underlying motive for the neurosis any form of treatment may only enhance the functional condition

Cases of compensation neurosis are alleged by some to be very rare while other writers place this as the commonest cause for neurosis. It is my opinion that these two views depend upon the number of compensation cases being handled by the various writers An industry or insurance company that adopts a liberal attitude toward compensation cases usually has fewer cases of compensation neurosis among the injured than does a company which has a hard boiled attitude.

Back cases which are purely compensation neuroses seldom yield to physical therapy An early settlement of the case usually results in a cure of the condi ion

Group III Traumatic Neurosis Remnants of the Organic Lesion Remaining with a Superimposed Neurosis —In this group careful search when applied to back cases will usually reveal the traumatic arthritis the thickened ligaments the contracted muscles the thickened aponeuroses and adhesions the sensitive nodes and similar conditions which are the aftermath of the original injury The neurosis must be treated by gaining the confidence of the patient as already detailed

Physical therapy in the form of heat massage exercise manipulation (often under anesthesia) occupational therapy and similar methods aimed at overcoming obscure but demonstrable organic lesions will usually cure this type of neurosis These patients usually misunderstood and neglected are the ones who respond most readily to and who are most grateful for treatment.

The dictum that you can rub more trouble into a neurotic patient in an hour than you can rub out in a month is true in a certain number of these functional neuroses Careful classification of the neuroses however will reveal a large number in whom physical therapy is definitely indicated The following case is an excellent example of a traumatic neurosis in a back injury

Case 12 —J A., a carpenter aged 42 married and with three children while working in a small community in southern Illinois in 1923 fell from a building a distance of 28 ft. injuring his back. X-ray facilities were not available to verify the diagnosis of broken back which was made in this case. He was treated in his home lying prone in bed for approximately six months He was finally awarded a total disability by the compensation board. He was referred to the author 16 months later to see whether anything could be done to decrease his per cent of disability At the first examination the patient had a resigned feeling-sorry for himself expression on

patient's confidence and refitting him for work. In some this can be accomplished in two weeks, in others it may take months. It is far better to persist in the treatment than to turn these patients loose as neurotics with continued disability Frequently they will leave the physicians and drift into the hands of cultists who will cure them simply because they have more time and patience and a better under standing of the psychology involved.

GROUP II TRAUMATIC NEUROSIS ORGANIC LESIONS CURED BUT DISABILITY PERSISTING DUE TO THE NEUROSIS —In back cases in this group when the neurosis is due to an exaggeration of the seriousness of the original trauma or the seriousness of the original accident, such patients should be handled as suggested under Group I

When the back neurosis is due to some erroneous idea or to an exaggeration of the seriousness of the injury often the result of some unguarded statement made by the attending physician, the idea must be wiped out before the neurosis can be overcome.

If a physician tells the patient that he has a "broken back" when the lesion is a simple linear fracture of a transverse process a neurosis frequently develops which prolongs the disability for months and sometimes years after the simple linear fracture has healed Sometimes during the acute stage the patient will complain of his suffering or of the length of treatment the physician, to justify his treatment sometimes replies "You are lucky to be alive " or "It will take a long time to get you well and you will never be completely well or "You will be permanently disabled ' Unguarded statements such as these form the basis of many traumatic neuroses and, of course should always be avoided

Recently I saw a patient suffering from a traumatic neurosis which was solely due to the fact that his family physician had written a letter at the request of the patient, stating that his patient had his skull fractured and was therefore unfit for jury service. Subsequent x-rays failed to show the skull fracture The patient had completely recovered from his injury within three weeks and was ordered back to work by this physician. Instead of going to work he developed symptoms of a true neurosis There were absolutely no organic findings. The under lying cause of the neurosis was the patient s inability to understand why his family physician had written that he had a skull fracture, then later told him that he did not have a skull fracture and continued to insist that he was able to go to work.

Physical therapy is indicated in this class of cases when stiffness of the back joints thickened ligaments contracted muscles, thickened aponeuroses faulty postures functional limps and general softening indicate the need of heat massage and exercise. The administration of some simple form of physical therapy thereby expressing the physician s interest in the case, combined with the physician's supervision, will go far toward overcoming this type of neurosis.

Fig. 17c.—Same as Fig. 17b showing method of securing knee flexion

Fig. 18.—Case f F B s1 years fter fracture of st lumbar vertebra, with im mediat paralysis due to compression of the cord and transfixion of the ord by splinter of bone transfixion. Laminectomy performed two hours after injury. Patient received physical therapy nd protection gainst foot drop continuously immediately following the operation. Within year he was walking

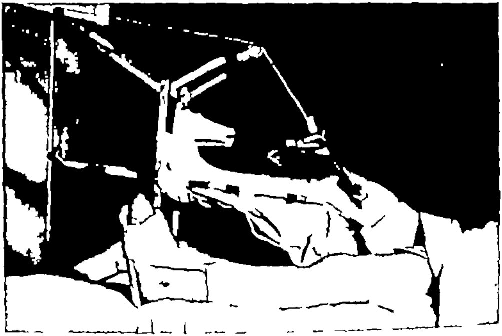

FIG. 17a.—Case of fractured 12th dorsal vertebra with complete paralysis following damage to the cord and complicated by fracture of the right femur. The femur is being treated by skeletal traction. Observe splints on each foot to prevent foot drop. Patient received massage, muscle training exercises and active exercise throughout her confinement in bed.

FIG. 17b.—Patient exercising her paralyzed left leg by means of a sling, pulley and rope.

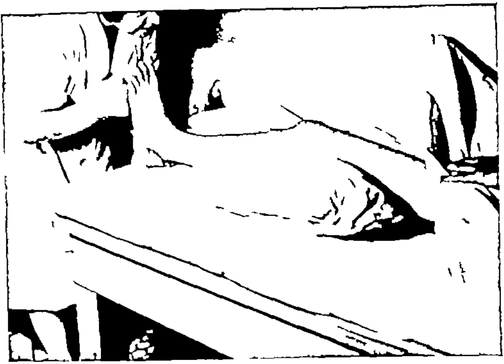

FIG 19b.—Patient receiving physical therapy and muscle training exercises.

FIG. 9c.—Same as Fig. 19b Complete recovery after two months. Bullet not removed.

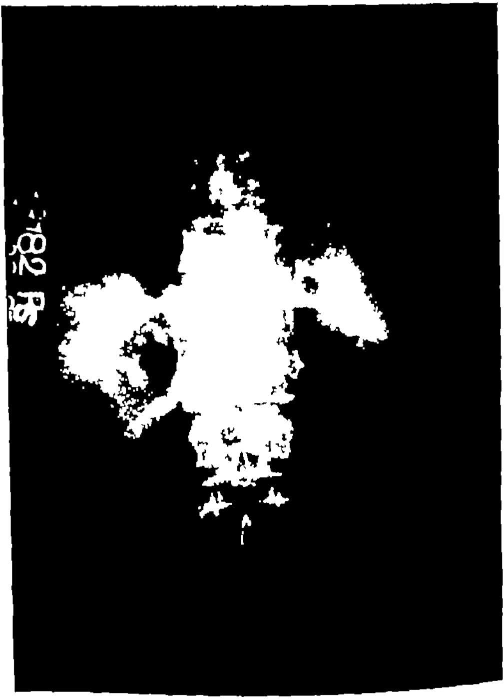

Fig. 192.—X ray of bullet wound of spine with hemorrhage about cord followed by extreme hyperesthesia and paralysis of left leg.

his face he stood with his feet a little apart and his back flexed about 10 on walking he took steps from 10 to 12 in. long and progressed very slowly movements of the back were slow and restricted the patient bending forward only about 25 and not being able to straighten his back completely he could raise his arms only slightly above a right angle to his body Physical and x-ray examinations were negative for organic disease There was no sign of a fractured vertebra Functional tests showed variations in pain and tender points along the spinal column with atypical areas of anesthesia. The observations were definitely those of a person with traumatic neurosis.

The patient was admitted to St Luke's hospital and was assigned to a regular routine of treatment consisting of periods of heat massage, exercise, tub baths, and rest. In addition to this he was assigned to the occupational therapy workshop for two hours a day at first, but the time was increased daily After about the fourth day it was noticed that the patient was spending all his spare time in the workshop He was asked to make a special splint for one fellow patient and to make the peg leg portion of a temporary artificial leg for another patient He was so handy with tools that he was soon acting as an assistant to the technician

At the end of two weeks the patient was walking with a normal stride could bend over and touch the floor could stand erect and could raise his arms over his head It was carefully explained to the patient that he had never had a broken back but that his trouble was all due to nervousness which he had overcome during these two weeks in the hospital, and he was discharged. Unlike many persons with neuroses he was extremely happy over his recovery and immediately returned home and went to work. Although the surgeon and the physical therapist were of some aid in his recovery the practical application of occupational therapy should receive the chief credit.

Conclusions

I have contributed this chapter as a surgeon confronted with a great many back cases and especially old back injuries which have failed to respond to other treatment. I am not a physical therapist. When physical therapy is necessary it is administered by qualified technicians under the direction of my associate Dr J S Coulter but I constantly supervise the case

I have found as the most valuable adjuncts to the surgical treatment of these cases various kinds of heat, various types of hydrotherapy and above all, massage and exercise. The exercise should be graduated from the simple contraction and relaxation of muscles while the patient is lying in bed to movements involving flexion and extension and lateral motion of the back exercises involving lifting and carrying the use of various kinds of apparatus such as a rowing machine and finally to the exercises involved in gradually increasing amounts of work, referred to as occupational therapy

In this chapter I have not dwelt in great detail upon the methods advocated for administering the various forms of physical therapy For details concerning the *modus operandi* of the various methods the reader is referred to the chapters on technic, Volume I.

FIG. 10—Compression fracture of 7th dorsal vertebra treated by hyperextension with body cast applied in position of hyperextension. The back of the cast cut out to allow massage of the back muscles. Patient was taught to shrug her muscles for active exercise. Complete recovery in nine weeks

CHAPTER SEVENTEEN

PHYSICAL THERAPY IN DEFORMITIES OF THE SPINE

R. B DILLEHUNT M.D

Perhaps in no instance is the adage an ounce of prevention is worth a pound of cure more applicable than in potential or incipient deformities of the spine. In joints of the extremities even when great deformity has been established surgical and mechanical measures are available which enable the most spectacular alleviation or correction But in severe deformities of the spinal structure which have once become confirmed and fixed with all the associated somatic and visceral pathology complete correction is practically never accomplished and even improvement is often almost unattainable The difficulty is due to the anatomic and physiologic complexity of the spinal bones joints and musculature and to the relative inaccessibility of the spinal column and thorax to the application of corrective measures in the form of apparatus dependent upon pressure for their corrective influence In other words since one cannot "get hold of" the spine with hands or apparatus to the degree that obtains with reference to the knee or elbow manipulative or corrective influences must be exerted less directly and therefore less effectively When one experiences the difficulty encountered in correcting an ordinary clubfoot in a child in which the foot and leg can be grasped powerfully in the hands and are seemingly under the command of the operator it can readily be appreciated how relatively little direct force one can exert upon a spinal deformity when one s efforts are applied to the pelvis thorax and axillae

It is therefore of the greatest importance that frequent examination be made of growing children to detect potential deformity and that preventive measures be instituted early So insidious is the development of spinal deformity not only in children as a result of congenital paralytic and postural causes but in adults incidental to postural mechanical or arthritic influences that the orthopedic surgeon seldom has opportunity to boast of having prevented deformity but he is constantly confronted with the problem of attempted correction which often results in no more than preventing it from progressing to a more severe degree. Since there are other chapters which deal with the principles of the prevention of deformity only the common types of deformity of the spine and the physical therapeutic measures designed for their alleviation or cure will be discussed here

Finally, I have treated in considerable detail the classification, etiology and diagnosis of back injuries in order to illustrate and stress the importance of a thorough understanding of the back condition before attempting any physical therapy measures

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Apart from actual operative surgical procedures the entire treat ment of spinal deformity is "physical therapeutic." The exertion of influence by push or pull or manipulation or traction whether from within by muscular effort or from without by manual or mechanical effort, is physical therapy hence one cannot exclude those measures applied by the surgeon and intelligently discuss those commonly delegated to the trained physical therapist because they are reciprocal parts of the same rationale

There are numerous deformities of the spine of congenital origin such as spina bifida synosteosis of vertebrae cervical rib variations in number and shape of spinal segments and other embryologic aberrations which may or may not produce deformity but which in any event are not amenable to physical therapy and are hence not discussed Moreover diseases of the spine such as tuberculosis syphilis and other granulomatous infections as well as osteomyelitis neoplasms and trophic disorders are not the subject of physical therapeutic ministration except in so far as they may produce deformity and are accordingly dealt with in other sections Similarly traumatic lesions comprise a special subject. Hence this chapter deals with deformities of the spine which may be considered to have been theoretically preventable and are capable of improvement by mechanical means whether of constitutional static, paralytic or arthritic origin.

Anatomic and Physiologic Considerations

Effective treatment of spinal deformity must be based upon a knowledge of the grosser and simpler principles of the structure and function of the spine. Although there are marked differences in structure and form between the spine of the infant, child, adolescent and adult, these differences do not materially modify the principles of treatment except in so far as the progressive decrease in resiliency and flexibility with advancing years makes treatment less and less effective therefore for the sake of brevity variations with the age of the patient will not be enumerated.

In general the spine is considered as that part of the vertebral column above the sacrum. It comprises about one-third of the length of the body and is composed of 24 segments the upper seven being designated as the cervical the eighth to the nineteenth inclusive as the dorsal, and the lower five as the lumbar The first cervical vertebra articulates with the base of the skull and the last lumbar with the sacrum which is solidly fixed between the two iliac bones forming with them the unyielding pelvic ring The sacrum represents the base of the spine being wider and thicker than any other vertebral segment, and the bony mass tapers gradually in anteroposterior lateral and axial dimensions from the sacrum upward so that the cervical vertebra is smaller in all diameters than the dorsal and the dorsal is

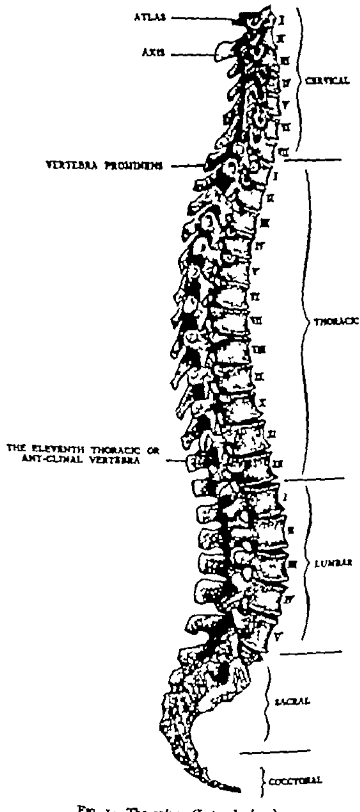

FIG. 1.—The spine (Lateral view)

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smaller and less massive than the lumbar, hence the column is pyramidal with its base below (Fig. 1)

Each segment or vertebra is in the form of an irregular osseous ring with a circular body flat above and below forming an anterior portion, and a posterior portion known as the arch made up of the laminae, spinous transverse, and articular processes The anterior and posterior portions are joined on each side by the short pedicle to form the ring (Figs 2 and 3) Thus the spinal column is formed of a series of super imposed rings each articulating with the one above, both in its an-

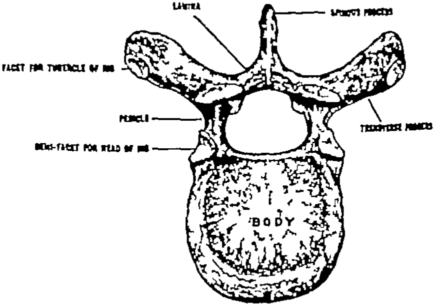

Fig 2 —A thoracic vertebra (Morris.)

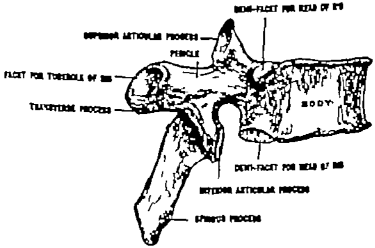

Fig. 3—A thoracic vertebra, side view (Morris.)

terior and posterior portions The bodies of the vertebrae are separated from each other by an intervening cushion of fibrous elastic tissue the intervertebral disc which fills the entire intervening space and is attached firmly to the vertebral body The disc projects a little beyond the rim of the vertebral body The periphery of the disc is firm and fibrous while in its center is a soft and movable fibrous mass the nucleus pulposus occupying little less than one-half the total area of the disc (Fig 4) The discs vary in shape and thickness in different regions of the spine In the cervical region they are thicker in front than behind thus necessitating the normal anterior convexity of the cervical spine Similarly in the lumbar region they are a little thicker

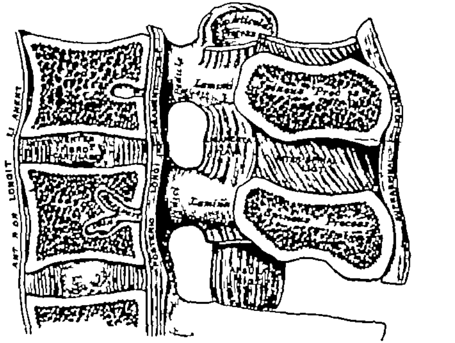

Fig. 4—Median sagittal section of two lumbar vertebrae and their ligaments. (Gray)

anteriorly causing anterior convexity and their general thickness here is greater than their cervical or dorsal thickness In the dorsal region they are more nearly symmetrical and the backward curve of the dorsal spine is due more to the shape of the vertebral bodies and to the necessity of its conformation in connecting a curve above and below The discs comprise 25 per cent of the total length of the spine hence in the aged in whom they become narrowed the spine is shortened and bent forward throughout.

The posterior portion of each vertebra articulates on each side with the one above by the articular processes producing joints which, in the cervical region are flat and slope backward and downward at an angle

smaller and less massive than the lumbar, hence the column is pyramidal, with its base below (Fig 1)

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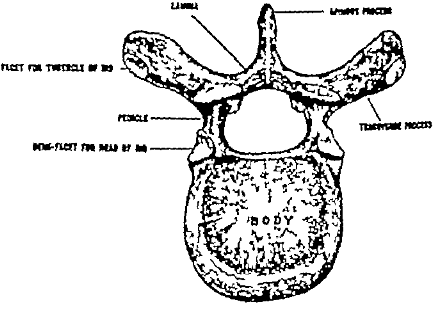


Fig. 2 —A thoracic vertebra (Morris.)

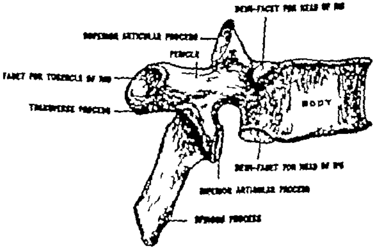


Fig. 3 —A thoracic vertebra, side view (Morris.)

importance in disordered states For detailed study of the musculature of the spine thorax and abdomen all of which must be regarded as controlling the spinal movements and stability the reader should refer to standard works on anatomy For the purpose of this discussion

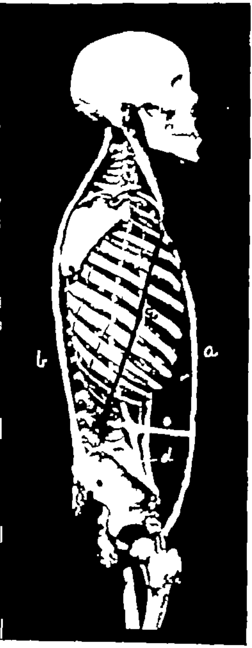


Fig. 5.—Normal physiologic curves. Skeletal support of thora and shoulder girdle

Fig. 6—Schematic representation of general muscular controls of the spine. (After Lovett) a and d flexor group control b extensor group control transverse group c rotator group

of 50°, in the dorsal region are more vertical and in the coronal plane, and in the lumbar region are nearly vertical and in the sagittal plane, with the exception of the lumbosacral articulations, which are more in the frontal plane thus permitting greater flexibility in the anteroposterior movements Thus each vertebra articulates with the one above at three joints, forming with each other a triangle It is difficult to see how there could normally be much movement between two adjacent vertebrae or even much movement in the entire spinal column, particularly in light of the fact that all three articulations are firmly surrounded by dense ligaments

The articulation of these segments results in an osseoligamentous column pyramidal in shape, containing in the canal produced by the foramina of the vertebrae the spinal cord and thus serving as an organ of protection Its other functions are maintaining the vertical position of the human body, sustaining the superimposed weight and support of the thorax, providing for flexibility and resilience, supporting and protecting the thoracic and abdominal viscera, and being the source of origin for a vast system of complex musculature.

To provide flexibility resilience and stability there are in the anteroposterior direction three curves, the cervical (convex anteriorly) the dorsal (convex posteriorly), and the lumbar (convex anteriorly) See Figure 1 These curves are known as the physiologic curves and their relationships to each other are of the greatest importance. The summit of the convexity of the cervical curve is at the level of the fifth cervical vertebra, that of the dorsal curve at the sixth and that of the lumbar curve, at the fourth In the transverse direction there is normally no curve except a slight deviation convexly to the right extending from the middorsal to the midlumbar region and said to be associated with the disposition of the vascular structures

Support of the thorax is afforded by articulations with the spinal column of the 12 ribs on each side (Fig. 5) From the second to the tenth ribs the head of the rib articulates with both the corresponding vertebra and the one below by a double joint, while the first rib usually articulates only with the body of the first dorsal vertebra, and the last two ribs with the eleventh and twelfth vertebrae, respectively Moreover the first to the tenth ribs have an additional articulation with the corresponding vertebra through their tubercles and the transverse vertebral process In this manner the thoracic cage is suspended and supported from the vertebral column and its shape is accordingly modified by changes in the relations of the spinal support.

Musculature of the Spine—Like all other joints or systems of joints the maintenance of stability strength and form is dependent not alone upon articular or immediate periarticular structures, but in great measure upon those extrinsic elements which normally affect the movement of the joint, namely the muscles and in the spine these are massive and complex in their normal states and of inestimable

viz. the sternocleidomastoid considered singly the broad strong external oblique muscle of the abdomen extending from the eighth rib downward, forward and mesially to be inserted into the sheath of the rectus abdominis Poupart s ligament, and the iliac crest. The internal oblique muscle of the abdomen is similar in arrangement except for obliquity in the opposite direction arising from the iliac crest and lumbar fascia to be inserted into the ribs sternum and rectus sheath.

Transverse—The transverse group (Fig 6c) is concerned chiefly with minor movements as far as the spine is concerned but effects concerted action of the upper extremity and thorax with the spine The pectoralis major and minor serratus magnus latissimus dorsi and trapezius effect movements of the shoulder girdle about the thorax and hence of the spine. Similarly the quadratus lumborum and transverse abdominal muscles effect movement between the thorax and the pelvis

It is important to consider the continuity of muscular action by these groups from skull to pelvis and even the lower extremities. It will be seen that the movements of the spine are determined and partly limited thereby and that deformity will ensue upon the release of control by any one group as in paralysis or upon the abnormal accentuation of the force exerted by any one or more groups as in muscle spasm incidental to inflammatory process or spastic paralysis. The equilibrium of the spinal mechanism at rest or in movement must be secured largely by the reciprocal action of all muscle elements

Movements of the Spine.—The voluntary movements of the spine are of course controlled by these longitudinal and transverse muscle pulls within the limits of range permitted by bone and joint elements The joints permit some movement between all vertebral segments although they are variable in different portions of the spine and the tripodal articulation definitely limits the range of movement enjoyed at each intervertebral joint The intervertebral discs are compressible and on movement adapt themselves in shape the nucleus pulposus slipping forward, backward or to either side. The articulations of the arch permit gliding movements only and so the net result is that each intervertebral joint can bend forward backward and laterally and can rotate In a system of superimposed joints of this sort the maximum mobility of the spine would be the summation of movements permitted by these articulations if the spine were a straight rod which it is not and if it were not for other factors of limitation such as the function of supporting the thoracic cage Thus the degree of movement and its nature are modified by the relatively fixed nature of the physiologic curves In the cervical region flexion extension lateral flexion and rotation are all free in range In the dorsal region extension is practically absent and flexion is limited while lateral motion is considerable. In the lumbar region lateral rotary movement is markedly restricted but flexion is freer and extension is freest

More important than the exact ranges of movement at different levels

consideration can be given only to the general gross arrangement of those groups which, acting harmoniously, prevent deformity and maintain stability, and the disturbance of any one of which may produce deformity

The spine must be regarded as the core of a cylinder of muscles which form the trunk, the core being situated posteriorly in the mass. The direction of muscular pull around the core is such that when all muscles are of normal integrity and hence balanced, they act as the physiologic splint of the spine and in every movement of any nature every portion of the splint participates.

MUSCLE GROUPS—There are in general four muscle groups (1) the extensor group, (2) the flexor group, (3) the rotator group, and (4) the transverse group

Extensor—The extensor group (Fig. 6b) is posterior to the spine, extending as a great mass from the pelvis and sacro-iliac ligaments upward on both sides to the base of the skull, with relays of origins and insertions. In addition to directly parallel longitudinal masses, portions at various levels curve laterally to insert into every rib and into the base of the occipital bone More deeply the interruptions are segmental so that the ribs are connected to the transverse processes of the vertebrae above, and to each other by intercostal muscles, and the transverse processes are joined by little muscle plates. This great mass imbeds the spine deeply except for the spinous processes, all of which can be felt subcutaneously between the two muscle columns.

Flexor—The flexor group is anterior to the spine and comprises two separate portions viz., those intimately connected with the spinal column and those of the anterior portion of the trunk. The former (Fig. 6d) consists of an upper portion or cervical group and a lower or lumbofemoral group between which in the dorsal region the continuity is deficient. The upper group arises from the bodies of the fifth and sixth cervical vertebrae and ascending in relays is inserted into the bodies and transverse processes of superjacent vertebrae and into the occipital bone The lower group the psoas mass arises from the bodies intervertebral discs and transverse processes of the twelfth dorsal to the fourth lumbar vertebrae inclusively and forms a belly which tapers downward over the brim of the pelvis laterally to be inserted near the lesser trochanter of the femur

The anterior trunk group (Fig 6a) is likewise interrupted in muscular continuity but by the unyielding sternum which subtends the defect. Above, the sternocleidomastoid muscles arise from the mastoid process of the temporal bone and descend to be inserted into the sternum and clavicle. Below the rectus abdominis extends from the thoracic rim in front to the pelvic brim below The anterior portion of the intercostal muscles may also be regarded as participating in this group

Rotator—The rotator group (Fig 6e) is composed of muscles of oblique arrangement with reference to head neck, trunk, and pelvis,

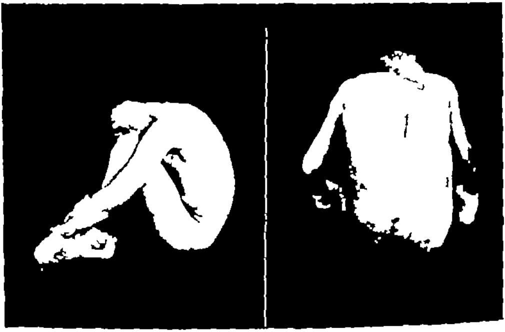
is the result of combinations of these in the spine as a whole for to the latter must treatment be accorded to affect any deformity Much of the seeming range of motion is really due to freedom of movement at the occipito-atloid juncture and at the hips hence the latter must be eliminated by fixing the pelvis to attain an accurate estimate Lovett [2] and others have emphasized the fact that in a flexible structure possessing fixed anteroposterior curves lateral bending is necessarily accompanied by rotation hence there can be no pure lateral movement of the spine without twist although at different levels the relative proportions of lateral motion to twist in this compound movement vary Moreover the ratio is varied by concomitant flexion or extension of the spine as a whole. For details of these elements the reader should be referred to Lovett s monograph, "Lateral Curvature of the Spine [2]

Figs. o and —Lateral flexion of the normal spine.

In general forward flexion is a pure movement enabling the conversion of the spine into a curve of approximately one-fourth of a circle (Figs 7 and 8) The physiologic lumbar curve is obliterated, the dorsal is increased, and the cervical is decreased

Extension is also pure i e. free from rotation and enjoyed to the degree shown in Figure 9 The movement is chiefly at the lower lumbar segments although the physiologic dorsal curve is somewhat decreased

Lateral flexion (and rotation) in the erect position resolves itself into a movement chiefly of the dorsolumbar region (Figs 10 and 11) and according to Lovett [2] is accompanied by rotation of the vertebral bodies toward the concave side of the lateral curve If however lateral flexion is carried out with the whole spine forward flexed a greater segment of the spine participates in the lateral curve and the vertebral bodies rotate toward the convex side thereof



FIGS. 7 and 8.—Flexion of the normal spine.

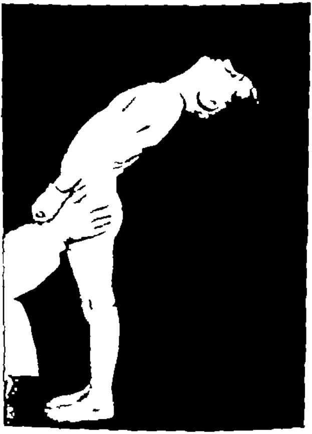


FIG. 9.—Extension of the normal spine.

below and by retentive apparatus in those cases exhibiting tendency to imbalance

Structural Curvature.—Structural scoliosis on the other hand is marked by the presence of deformity which a normal spine cannot assume and by definite changes in the form and relation of the bony

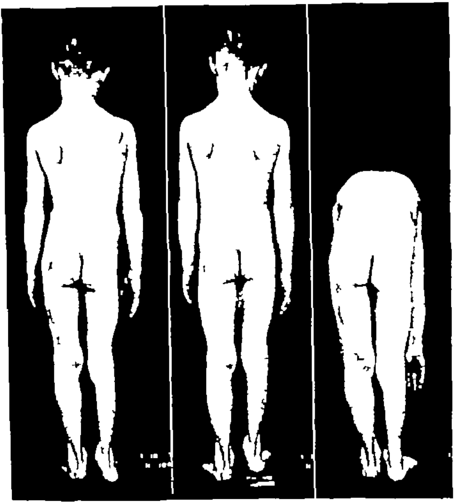


FIG. 12—Functional scoliosis compensatory to short right lower extremity
FIG 13—Obliteration of deformity of spine by raising right lower extremity
FIG. 14—Absence of rotary deformity (structural) in forward flexion

elements of the spine These bone changes may be primary with reference to the scoliosis as in congenital malformation of bone such as 'wedge vertebrae and other developmental anomalies of segments or articulations or in changes in the shape of these elements due to rickets neoplasm granulomatous disease or trauma

Lateral flexion and rotation being indissolubly associated and reciprocal the effort to eliminate one mechanically tends to restrict the other in the normal state, while the converse is true in certain deformities

To summarize, the anteroposterior normal curves together with the segmented osseoligamentous structure assure a flexible mechanism of stability and equilibrium capable of generous mobility as a whole and requiring very little external support to maintain symmetry The spine is, however, provided with abundant muscular support, which if balanced, augments these factors and which, if unbalanced inflicts deformity Manifestly the plasticity of the structure has much to do with its vulnerability to deformity from external influences Thus in the mature spine marked degrees of muscular imbalance may be effectively resisted while in the immature spine minor degrees of imbalance may gradually produce extreme deformity Moreover intrinsic factors and extrinsic influences other than muscular imbalance may be the elements originating deformity, but once instigated, imbalance ensues and augments deformity

General Scoliosis (Lateral Curvature of the Spine)

Functional Curvature.—Lateral curvature of the spine may be functional i.e., unaccompanied by permanent anatomic change in the bones. Such deformity may exist as a normal compensatory reaction to a short lower extremity from any cause (Figs. 12, 13, and 14) There is a singular lack of tendency for such a spine to develop structural deformity Moreover in hysterical curvature, although the apparent deformity is obtrusive there is no structural change. Obviously such forms are not the subject of physical therapeutic ministration. However another form of lateral curvature primarily apparently functional not uncommonly becomes habitual and may progress gradually into structural changes. This form occurs without apparent cause, usually between the ages of 6 and 12 and is nearly always a deviation to the left. The curve is general i.e extends throughout the length of the spine the maximum deviation being at the level of the ninth or tenth dorsal vertebra. Such a deformity is called a "total" curvature and is usually so gentle that the maximum deviation does not exceed as a rule two inches from the median line. Slight degrees of this type may be overlooked There are no supplementary or compensatory curves and torsion has not occurred but there is elevation of the left shoulder which is also displaced forward, while the right is displaced backward and the whole trunk is shifted toward the left, as indicated by the plumb line dropped vertically through the fold between the buttocks (Figs 15 16 and 17)

It is therefore essential that balance be maintained during the years of growth to avert conversion to the structural type. This is accomplished by general calisthenics for the spinal musculature described

static factors plus muscular imbalance incidental to the musculature of one side operating to a mechanical disadvantage against that of the other tend not only to perpetuate but to increase the deformity in just the same manner as these influences operate upon an ankle joint Now when one of these influences is exerted with sufficient persistence in point of intensity and time particularly upon the growing spine a curve to the right or left is created and such curve is greater than the normal physiologic movement which the spine could assume in that direction The convexity of the curve will be opposite the side in which contractural causes operate and usually on the opposite side to the paralysis in unilateral poliomyelitic scoliosis.

As has been pointed out, the spine cannot be bent laterally at any given point beyond a certain limit without introducing the element of rotation or twist, and when such lateral curve is toward the right, the direction of the rotation of the segments is toward the right In other words the vertebral bodies rotate toward the convexity of the curve This torsion occurs not only between the vertebral segments but actually in their bodies When the curvature is in the dorsal spine the ribs on the convex side are curved backward with the rotating vertebrae creating the "rotation hump" or gibbus. As the curve develops and the rotation occurs there is crystallization of the stress of superimposed weight upon the portions of the vertebral bodies on the concave side and in response to Wolff's law they become wedge-shaped (the base laterally) and otherwise distorted Torsion is not confined to the immediate vicinity of the lateral curve but goes on above it so that there develops a twist of the shoulders in relation to the pelvis

The ribs on the concave side are carried forward accentuating the hollow in the back on that side and the thorax thus becomes deformed Attempted adaptive and compensatory adjustments resolve the deformity into one that must be regarded as no longer of the spine alone but of the entire body The patient in an involuntary effort to compensate for such a disturbance of mechanics shifts weight to the extremity on the side of the convexity and general disalignment of trunk and extremities ensues.

Untreated structural scoliotic deformity does one of two things either it becomes spontaneously arrested at a certain point and the patient goes through life without serious disability or it progresses gradually to a degree that terminates life at a comparatively early age In the latter deformation of the thorax distorts and compresses the respiratory and circulatory viscera impairing the functions of both and resulting in impaired aeration and circulation lowered resistance emaciation and susceptibility to secondary infection. The thorax collapses into the pelvis until the ribs impinge upon the ilium, inflicting similar embarrassment upon the abdominal viscera. Such individuals seldom reach advanced years being carried off by pneumonia or other terminal disease

Much more commonly, however, the osseous malformation is secondary to an extrinsic factor, acting to produce deformity gradually Of these infantile paralysis is by far the most common, as indicated by the fact that it caused 80 per cent of my cases Other forms of paralysis, such as meningomyelitis, spastic paralysis, and dystonia muscu

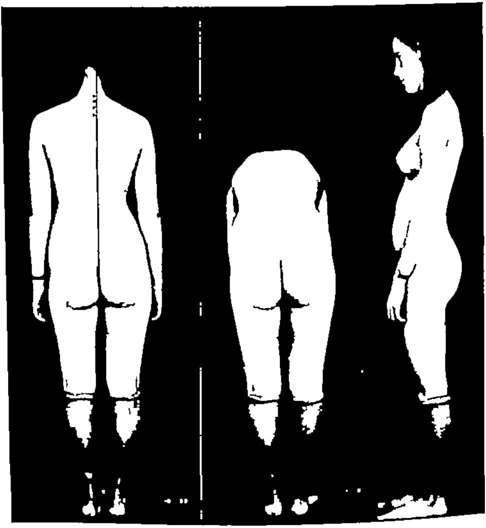


Fig. 15.—Total scoliosis (early functional)

Fig 6.—Same as Fig. 5 flexed. No rotary fixed deformity

Fig. 7—Same as Fig 15 lateral view Note general slouching attitude typical of prescoliotic posture

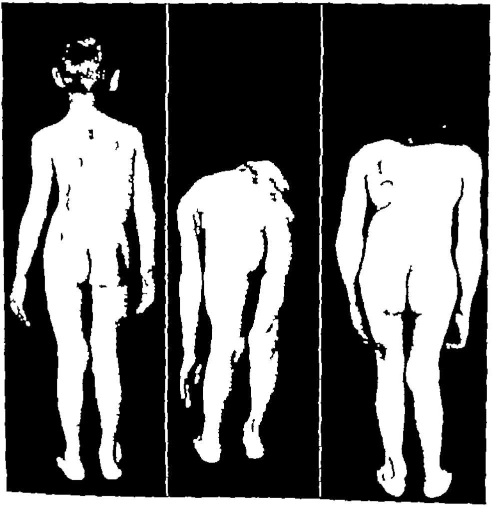
lorum may create imbalance to the degree of structural change. Contracture of one side incidental to cicatrization of pleurisy or empyemic process or traumatic lesion of chest cavity wall or even skin may result in structural scoliosis

No matter what the origin once structural change is established

2 Acquired scoliosis

A. Anatomic asymmetry outside the spine
   1 Torticollis
   2 Asymmetry of the pelvis
   3 Unequal length of lower extremities
   4 Ocular asymmetry

B Disease of bones or joints of the spine
   1 Rickets
   2 Tuberculosis of the spine
   3 Arthritis of the spine
   4 Osteomyelitis of the spine
   5 Tumors
   6 Fracture or dislocation

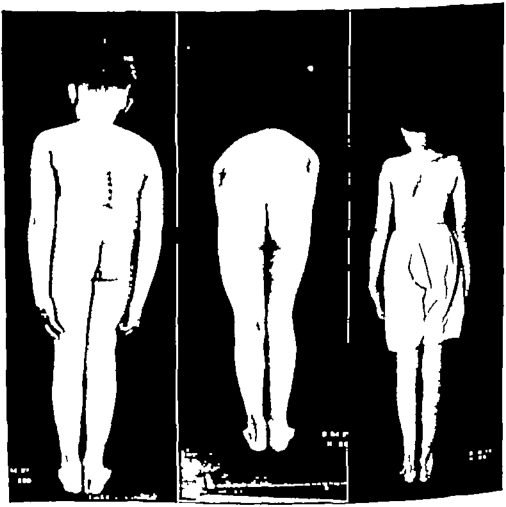


Figs. 1 and 2—Scoliosis due to rickets
Fig. 3—Scoliosis due to chondrodystrophy (kyphoscoliosis)

Etiology —Inasmuch as the wisdom of attempting treatment at all and the prospect of any success depend to a considerable degree upon the extent and degree of fixation of the deformity and the causative agency, one considering treatment should recall the many etiologic factors in this deformity These may be summarized as follows

1 Congenital scoliosis

   A Developmental anomalies of the vertebrae
      1 Wedge-shaped vertebra (one or more)
      2 Absence of one side of vertebra (one or more)
      3 Fusion of two or more vertebrae on one side
   B Embryologic malformation of the thorax
   C. Deformity *in utero* from pressure



Figs 18 and 19 —Congenital scoliosis due to wedge-shaped vertebrae.
Fig 20.—Acquired scoliosis secondary to left torticollis.

It is evident in regarding the list of causes that many will not yield to physical therapeutic measures and that surgical or other orthopedic procedures directed toward the underlying pathology are indicated. Illustrations of scoliosis from different causes are shown in Figures 18 to 27 inclusive. (Figs 18 and 19 show the congenital Figs 20-27 show the acquired.)

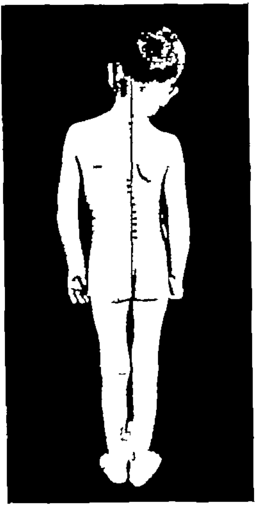


FIG. 27.—Scoliosis due to contracture of right thoracic cavity following old empyema.

Treatment.—*Prophylactic*.—*Prevention* as in all other deformities is of the greatest importance Routine examination of school children will aid in the early recognition of beginning deformity or prescoliotic evidences Congenital scoliosis can thus be recorded watched and controlled. Prescoliotic indications such as the inclination to assume asymmetrical attitudes in standing or sitting or postural slouches ocular deviations and rachitic round back, accompa

7 Osteochondritis
8 Dyschondroplasia and chondrodystrophy

C Deformity due to disturbance of muscle balance
1 Infantile paralysis
2 Spastic paralysis
3 Dystonia musculorum
4 Inflammatory or traumatic muscle spasm lumbago, sciatica sacro-iliac disease hip joint disease
5 General muscular atony from any cause
6 Muscular dystrophy
7 Encephalitis lethargica

D Contracture of extrinsic soft structures
1 Unilateral pulmonary disease
2 Thoracic empyema
3 Cicatrization of the skin from burns or other trauma

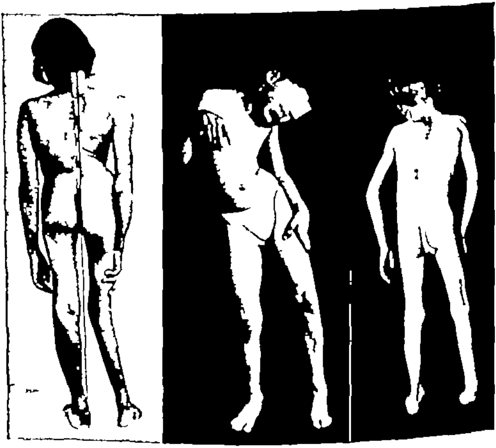


FIG. 24.—Scoliosis due to infantile paralysis which has affected musculature of spine, abdomen and right lower extremity

FIG. 25.—Scoliosis due to dystonia musculorum.

FIG. 26.—Scoliosis due to postencephalitic Parkinsonism.

curve I have referred to the associated torsion that occurs and to the tendency for imbalance to occur in the entire body For instance when there is a dorsal curve to the right, in order to retain the center of gravity the body weight is shifted more to the right lower extremity than to the left. This is an early effort of the body to compensate mechanically Later there develops a curve above and below the primary one in a further effort to establish the center of balance. These curves are known as secondary curves and are in a direction opposite to the primary curve In this automatic adaptation the body may succeed or fail In those cases that become stationary or nonprogressive the secondary curves and the primary one have become reciprocally compensated and although there are three curves in the spine the net

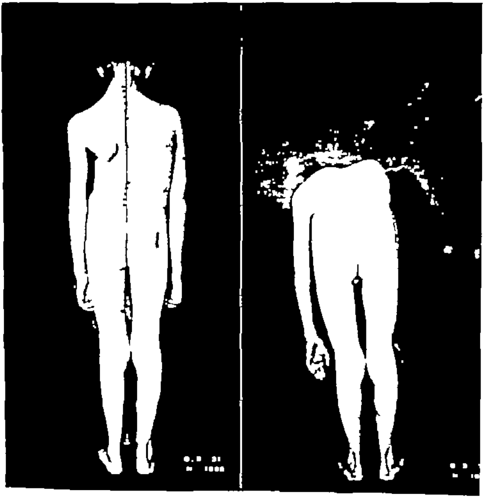


FIG. 18—Example of compensated scoliosis. Although there are structural change and deformity the plumb line falls through center of skull and internatal fold and weight is borne equally on lower extremities, i e., there is no list

FIG. 19.—Same as Fig 18, flexed, disclosing torsion def rmity

nied by other evidences of rickets, can be met in advance of real deformity, and by supervision, exercises, and sometimes apparatus, can be controlled during the growing period Scoliosis can thus be averted

Of particular importance is a careful study of the spines of children who have had infantile paralysis Extreme degrees of paralysis may result in little deformity owing either to retention of balance despite loss of power, or to maturity of osseoligamentous structure. On the other hand seemingly minor degrees of unilateral spinal or abdominal paralysis may result in extreme degrees of deformity and often following a latent period of years. Moreover many children have mild attacks of poliomyelitis without its having been recognized but months or years later the scoliotic deformity is observed. Once launched upon the tendency, progression of the deformity is likely to go on apace, and often in spite of intensive opposition in the form of treatment.

Indications and Contraindications.—The principles of treatment in the paralytic type are applicable to all forms in which underlying pathologic causes such as tuberculous spine, arthritis, etc., do not contraindicate movement and hence movement is selected as the basis for outlining the routine

The question should be asked first, "Can anything be expected of treatment? The answer is to be sought in the degree of fixation of the deformity and in the determination of whether it is definitive and stationary In the inveterate contracture in the adult there is no prospect of correcting the deformity In the stationary scoliosis which has arrived at a state of compensation and is not progressing in either adult or child it had best be let alone as far as efforts to reduce deformity are concerned.

Purpose of Treatment —The second question to be asked is, "What are we trying to do?" If the answer to the latter is the attempt to unbend and untwist a structural lateral curve and to secure the normal anatomic relation of distorted vertebrae the optimism exceeds that of anyone who has had experience in the subject. The multiplicity of methods and machines directed to this end testifies to the improbability of such accomplishment

Arrest of Deformity.—Attention has been called to the fact that structural scoliosis untreated either progresses to a hopeless degree or assumes a definitive state The ideal of treatment in our present understanding of the subject is to secure the definitive arrested state with the maximum of correction by the application of those measures which convert the progressing deformity into the status of the one that has become spontaneously arrested This leads to the question "What occurs spontaneously to arrest deformity in this type? It is generally accepted at present that this is accomplished by the development of compensatory balance. During the development of a primary scoliotic

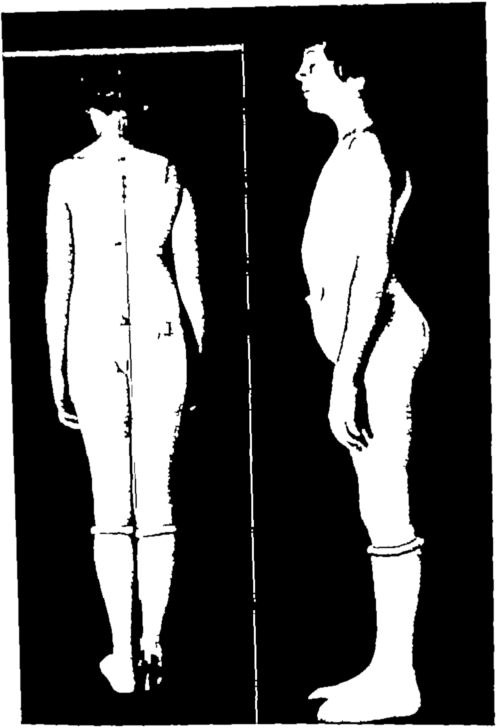


FIG. 30.—Prescoliotic attitude. Lateral curve without structural change. Potentially inclined to become progressive and develop structural change.

FIG. 31.—Lateral view of Fig. 30, indicating tendency to slouch.

result is realignment of the whole so that imbalance has been corrected. In such a case the plumb line will fall through the median line of the cervical vertebrae and through the internatal fold, although the spinous processes will deviate from the line in three areas (Figs. 28 and 29) Now to disturb this mechanism by attempted correction of deformity is to court the danger of breaking the compensation and making the patient worse. Such a spine has already attained the nearest ideal toward which treatment strives, namely the establishment of compensation Every scoliotic spine makes the effort to do this automatically, but many fail Treatment is directed toward helping in that direction.

To this subject most salutary contribution has been made by Steindler[3] and his conceptions are utilized as the basis of the treatment given herein.

Rehabilitation of Muscles—In the potential scoliotic patient before structural change has occurred (Figs 15 16 17, 30, and 31), viz., the type of child that assumes asymmetrical attitudes in walking, standing or sitting and in the patient whose general musculature has been subjected to deterioration by prolonged illness or recumbency for any reason the object of treatment is the rehabilitation of the normal splints of the spine—the muscles Supervised exercises designed to bring into play all the intrinsic and extrinsic musculature effecting spinal integrity are instituted. It is to be assumed that general physical examination has determined whether such a régime is compatible as indicated by the cardiovascular respiratory and general conditions. Exercises must be graded carefully, according to the requirements and the capacity of the child In no instance should either child or muscle be subjected to exercise to the degree of fatigue or weariness. Thus it may be advisable to subject each muscle group to no more than one or two contractions in the beginning until each can be accomplished with ease and grace It is important that the therapist be cognizant of the fact that no amount of passive ministration to a muscle in the form of massage can be substituted for voluntary contraction in restoring tone and strength and passive ministration in these cases should be limited merely to the touch to indicate to the patient the direction of voluntary effort. However, when the latter is insufficient to accomplish a given movement, it should be performed with the passive aid of the therapist until the therapist's assistance is no longer needed The method of conducting exercises with passive aid is described below under Exercises B

The exercises designed to strengthen all spinal musculature indicated below under Exercises A, are properly used as supplementary to other more specifically directed treatment in cases of established scoliosis

Such exercises may be given in classes but only after each member understands the procedure and has developed a fair degree of muscle capacity through preliminary individual work.

Structural Scoliosis of Paralytic Origin

Diagnosis.—It is assumed that a structural curve has developed The first procedure is the securing of proper records These include in addition to the general physical and orthopedic examination photographic and radiographic records made under standard technic Posing for the photograph is ideally done under the direction of either surgeon or physical therapist. The spinous processes are marked with black court plaster and a plumb line of black is dropped vertically through the internatal fold to determine the median line The patient stands in natural relaxation with heels parallel to the lens of the camera Light distance, and exposure must be invariable if photographic records are to be of value for comparison This view discloses the location and degree of deviation of spinous processes from the median

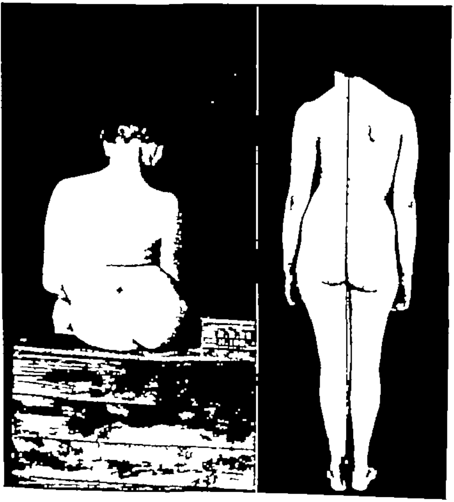


FIG. 34.—Scoliosis lumbodorsal, structural, left infantile paralytic, severe.
FIG. 35.—Scoliosis cervicodorsal, structural right, moderately severe.

In the patient whose muscular structure cannot maintain symmetry and balance, the treatment should be supplemented by a light back brace and an abdominal support or a corset (Figs 32 and 33) In the event that the examination and the experience of the therapist disclose that the musculature of one or more groups is weaker comparatively than that of others, particular attention should be given to that group, and in such cases external support is particularly indicated.

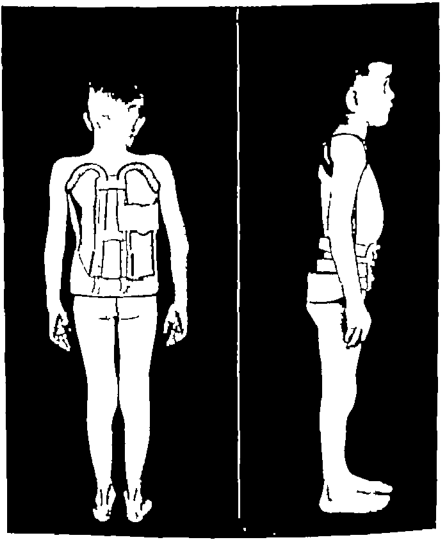


FIG. 32—Type f brace for support of prescoliotic patient between exercises. To be worn most of the time when up and about until musculature ppears competent. The brace must be light, hence it should be made of aluminum and adjustable posteriorly and laterally

FIG. 33—Another type light but effective brace.

line and the shift of the trunk to one side or the other The second exposure, which is made from behind with the spine *flexed* records the degree of torsion as indicated by the gibbus which is on the convex side of the curve in structural cases and in the same area as the primary curve. If it is on the opposite side the case must be regarded as functional scoliosis (Fig 14)

The degree of rotation of the trunk is estimated by looking down ward from above behind the patient and determining the relation of *the scapulae or shoulder girdle to the pelvis*

Radiographic study is made of the whole length of the spine antero-posteriorly not only to determine the degree of primary and secondary curves, but to note the extent of deformity in the vertebrae and ribs

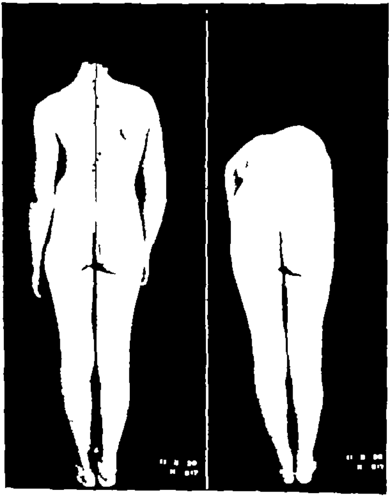


FIG. 39—Compensated right dorsal structural scoliosis N list axial balance maintained for years.

FIG. 40—Compensated right structural dorsal scoliosis, exhibiting degree f rotary deformity

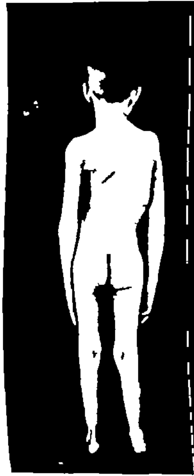


FIG. 36.—Determining flexibility Right structural paralytic dorsal scoliosis, standing naturally

FIG. 37.—Determining flexibility Application of head traction apparatus.

FIG. 38.—Determining flexibility Traction applied. Note extreme flexibility as indicated by great decrease of deformity and lengthening of the trunk.

ing it Determination at this point must be made as to whether the case at hand is in a state of compensation. If so the future treatment should be directed toward keeping it so if not, it should be designed to make it so

By compensation is meant the state in which the primary and secondary curves and torsions counteract each other to the degree that the central axial line remains vertical and central thus maintaining balance (Figs 39 and 40)

By decompensation is meant the absence or insufficiency of compensatory secondary curves permitting shifting of the whole superimposed trunk to one side with the pelvic center in one axis and the cranial center in another creating leverage which adds the effect of

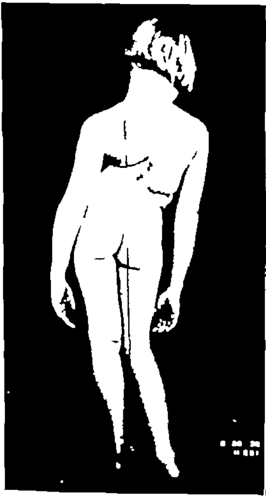


Fig. 43 —Decompensation (advanced) in right structural dorsal scoliosis. Note extreme list, complete loss of center of gravity and absence of compensat ry curves.

Fig. 44 —Same as Fig 43

Observation should also be made in the prone position for therein the functional curve disappears and the structural curve is modified by relief from superimposed weight

Descriptive record is thus made as the diagnosis Scoliosis is described as to the location of the primary curve the degree thereof (whether it is structural or functional), and its etiology For instance

Scoliosis lumbodorsal structural, left, infantile paralytic, severe (Fig 34) or scoliosis cervicodorsal, structural, right, infantile paralytic, moderately severe (Fig 35)

The flexibility should be recorded because of its important relation to treatment It may be visualized by suspension of the trunk by the head (Figs 37 and 38) The more rigid the spinal curve, the more resistant it is to continued increase in itself and to efforts at decreas-

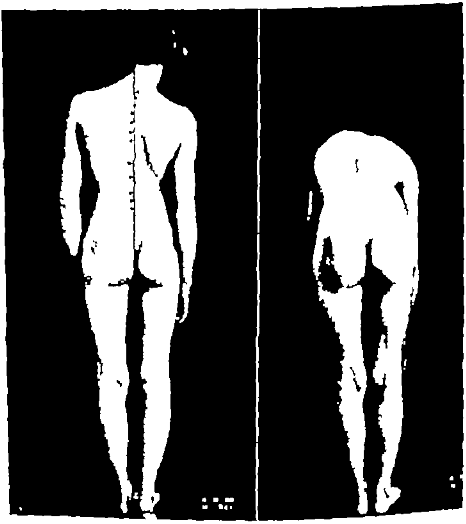


Fig. 41 —Decompensation (early) in left dorsal scoliosis. Note list to right and absence of compensatory curves

Fig Same, revealing rotation.

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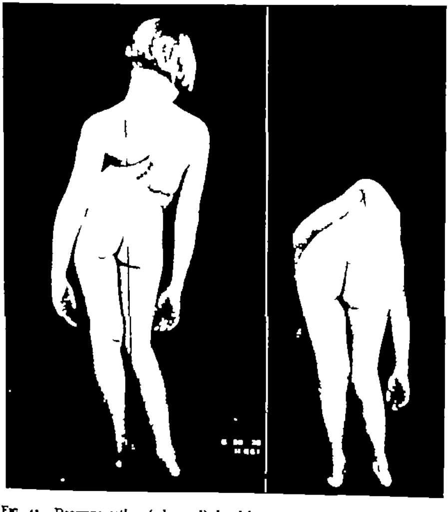

FIG. 43—Decompensation (advanced) in right structural dorsal scoliosis. Note extreme list, complete loss of center of gravity and absence of compensatory curves.

FIG. 44—Same as Fig 43

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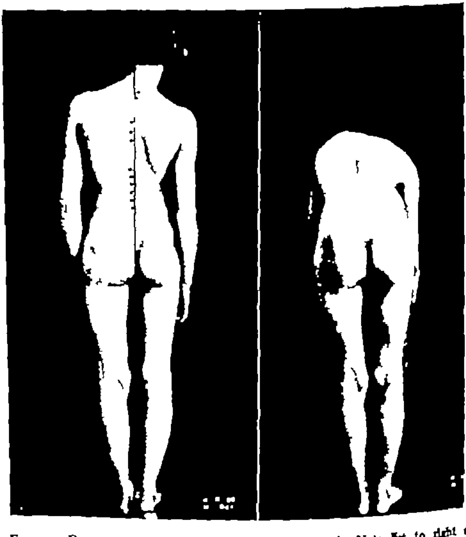


FIG. 41—Decompensation (early) in left dorsal scoliosis. Note list to right and absence of compensatory curves

FIG 4 —Same, revealing otation.

At any time, particularly during the growing period the compensated scoliosis may lose its balance and become decompensated and then the primary curve progresses and the secondary curves become relatively decreased This breaking' of compensation occurs most commonly at the lumbodorsal juncture. It is possible in some instances to regain compensation by means of a brace and exercises and passive efforts at reversing the direction of the leverage of superimposed weight. These are outlined below under shifting exercises. This régime

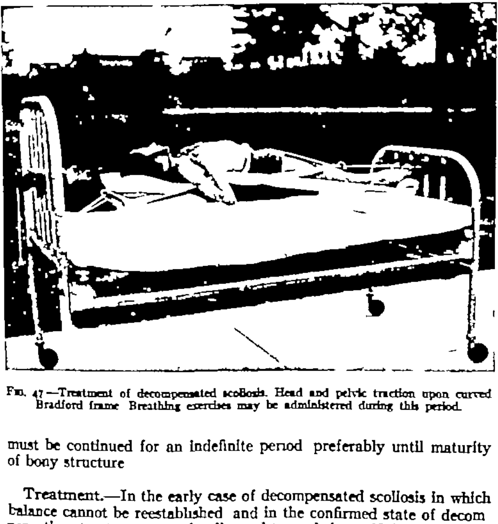


FIG. 47—Treatment of decompensated scoliosis. Head and pelvic traction upon curved Bradford frame Breathing exercises may be administered during this period.

must be continued for an indefinite period preferably until maturity of bony structure

Treatment.—In the early case of decompensated scoliosis in which balance cannot be reestablished and in the confirmed state of decompensation treatment must be directed toward the artificial creation of compensatory curves and the maintenance thereof by apparatus and toward the rehabilitation of the musculature in its new relation to enable it to maintain the curves without apparatus Failing in the latter one has the choice between continued apparatus and operative ankylosis of part or all of the primary curve and part of the secondary curve

gravity to the contractural element of the primary curve, and causing it to collapse further (Figs 41 46)

In the compensated type the record must be kept for comparison at intervals to detect evidences of decompensation, and treatment consists in exercises for the prescoliotic patient as outlined above and in special corrective exercises indicated below (Exercises C)

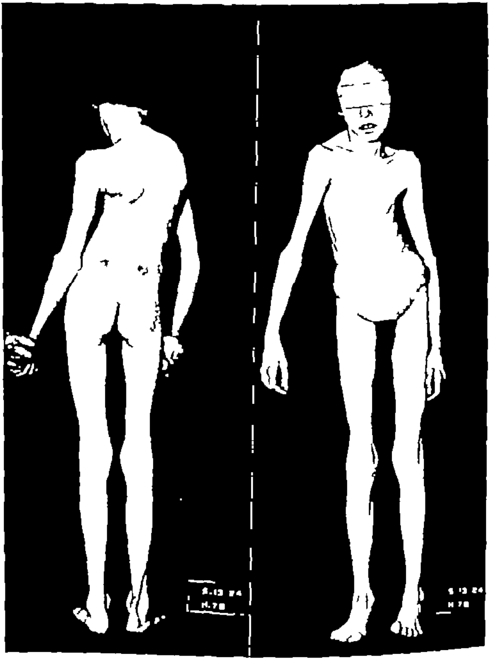


FIG. 45.—Same as Fig 44.

FIG. 46.—Confirmed decompensation Fixed spine in extreme disalignment deformity of thorax and impairment of general health.

the gymnasium for the exercises (Fig. 47) The latter, both active and passive must be directed toward mobilizing the lumbar and cervicodorsal portions of the spine as described in Exercises C and D

The establishment of compensatory curves or the beginning thereof requires several weeks When the curves have been attained to the degree that the mobilized spine may be passively placed in an attitude which is the reverse of its former inclination viz. with the summation of the upper and lower curves equal to the primary one and with the pelvis rotated to the side opposite its former relation to the shoulders a plaster jacket and spica are applied to retain this correction the jacket being provided with windows for pads to accentuate it (Figs. 48 and 49)

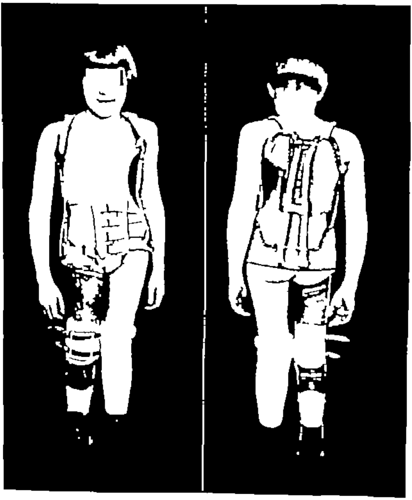


Fig. 50.—Same as Fig 48, anterior view

Fig. 5 —Brace used for support after removal of plaster dressing.

ARTIFICIAL CREATION OF COMPENSATORY CURVES —Older forms of treatment consisted of energetic, forcible redressment, stretching, and apparatus designed forcibly to unbend the primary curve a procedure now considered inadvisable because it removes one quality of service in preventing further deformity, viz, the rigidity of the primary curve. In less forcible application of such measures, although clinically and radiographically there appears to be a decrease in the primary curve, the important result is the formation of new curves above and below To enhance the latter, the unfixed portions of the spine are limbered by gymnastics mobilizing exercises, and head and pelvic traction in recumbency The patient is maintained on a Bradford frame, with traction upon the head and the pelvis, and is removed twice daily to

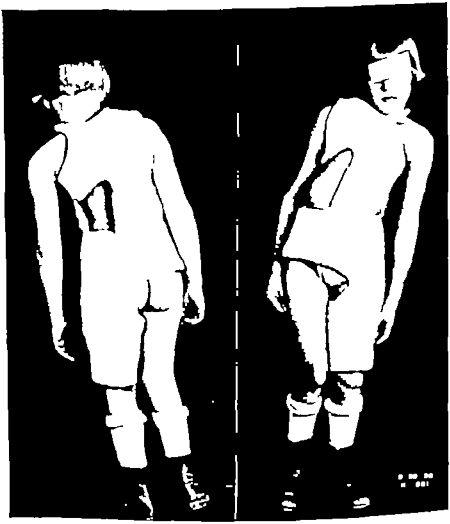
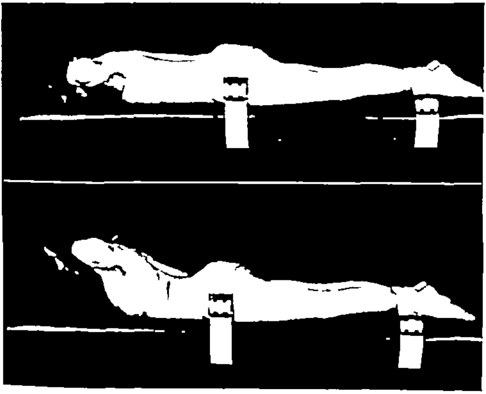


FIG. 48 —Plaster spica applied after establishment of compensatory curves to maintain them and increase them by securing rotation while pads are inserted through fenestrae. (Same case as Figs. 43 and 44.)

FIG. 49 —Same Anterior view

for the spine (B) passively aided muscle training (C) asymmetric muscle training in particular deformity (D) passive manipulative procedure to mobilize the spine and create compensatory curves

SYMMETRICAL MUSCLE TRAINING—The object to be attained is equal development of the spinal musculature—viz the extensor flexor lateral flexor and rotator groups This is best done with the patient recumbent, when the factors of weight bearing in the upright



FIGS. 52 and 53—Extensor muscle training.

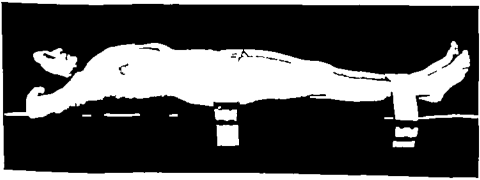


FIG. 54.—Flex r group training

The plaster is applied with head traction with the patient in the standing position The arm on the side opposite the curve is strongly elevated The lower extremity on the same side, i e. opposite the convexity, is abducted This position accentuates the secondary curves. The trunk is steadied by pressure over the anterior and posterior prominences of the deformed thorax and while the patient assumes the attitude of the shift, the plaster is applied from neck to knee on the abducted side, rotary relation of pelvis and shoulders also being secured

A fenestra over the gibbus permits insertion of felt pads from time to time (Fig 50) The child may be up and about and the plasters may be changed at intervals for a period of from three to six months.

Upon the removal of the plaster a brace is applied to retain the positions secured by the plaster (Fig 51) and physical therapy is resumed consisting of shifting and the general calisthenics outlined. Photographic and radiographic records are again made for comparison months and years hence. The problem now is to retain what has been accomplished The general exercises and brace are to be continued for two years at least. Swimming and the ordinary activities should be encouraged within reasonable limits

In addition to the general exercises outlined breathing exercises, both naturally and by expiration against resistance with Wolff bottles, are valuable in cases in which the thoracic area has been encroached upon by deformity

Recurrence of decompensation justifies repetition of the whole procedure and fusion in selected cases.

REHABILITATION OF MUSCULATURE PHYSICAL THERAPY —The part of the physical therapist in scoliosis may thus be summarized

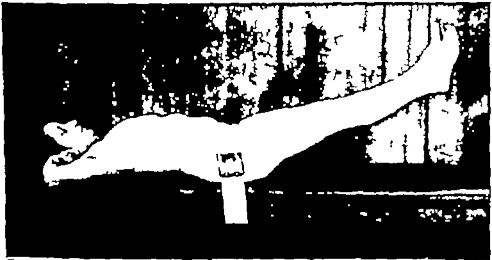
(1) Potential scoliosis
   a. General muscle training posture work
(2) Compensated scoliosis
   a. General muscle training
   b Shifting exercises
(3) Decompensated scoliosis
   a. Mobilization exercises
      1 Creeping
      2 Passive stretchings and torsions
   b Retentive exercises
      1 General muscle training
      2 Swimming
      3 Breathing exercises
      4. Shifting exercises

For the purpose of description the technic (consisting of exercises) will be divided as follows (A) symmetrical general muscle training

54 57 the lateral flexor groups as in Figures 58 60 and the lateral and rotator groups as in Figures 61 and 62

PASSIVELY AIDED MUSCLE TRAINING —When the patient cannot voluntarily accomplish one or more of the group movements the voluntary effort is augmented by the therapist s passive aid It may be advisable to commence with a limited range of the desired move ment and gradually increase the range The application of passive aid to muscle training is illustrated in Figures 63 to 73 inclusive

ASYMMETRICAL MUSCLE TRAINING AND MOVEMENTS —This group of exercises is used in the compensated scoliosis to assure its maintenance in the early decompensation to attempt to regain compensation and in the decompensated case while undergoing traction in bed to create compensatory curves The technic varies with the deformity at



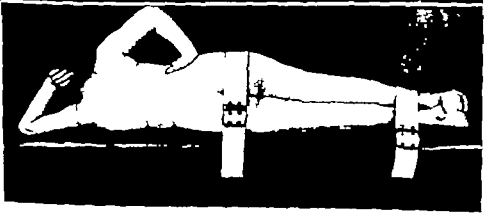
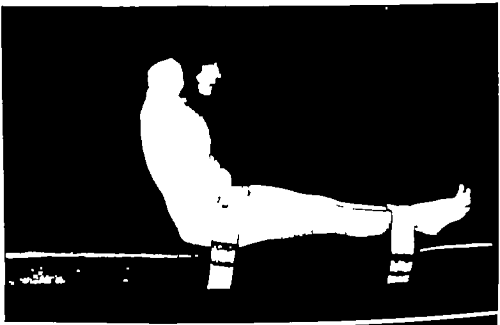


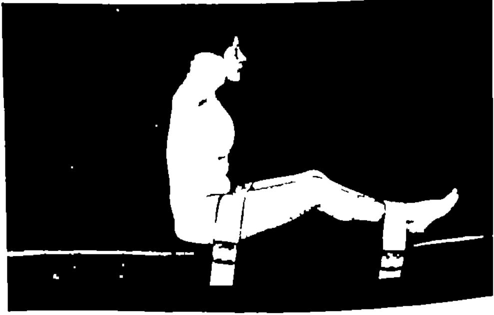
FIG. 57 —Flexor group training

FIG 58 —Lateral flexor training.

position are removed By test it must be determined whether the patient is capable of carrying out the movements If one or more movements are especially weak it is well to neglect the others and to concentrate on this one with passive aid as described under 'B"

Shifting and insecurity of the pelvis must be eliminated by strapping Movements must not be hurried or jerky, but slow and complete in range The illustrations are self-explanatory The extensor group is trained as in Figures 52 and 53, the flexor groups, as in Figures





Figs 55 and 56—Flexor group training.

the balance The exercise is carried out several times within the limits of fatigue

These are supplemented by the *creeping exercises* described by Klapp [1] (Figs 78-72) Locomotion by means of hands and knees is a general exerciser of spinal musculature if done symmetrically and when carried out asymmetrically it both mobilizes and exerts a corrective influence The movements are carried out with a voluntary stretching of the concavity of the scoliosis at each upward and forward

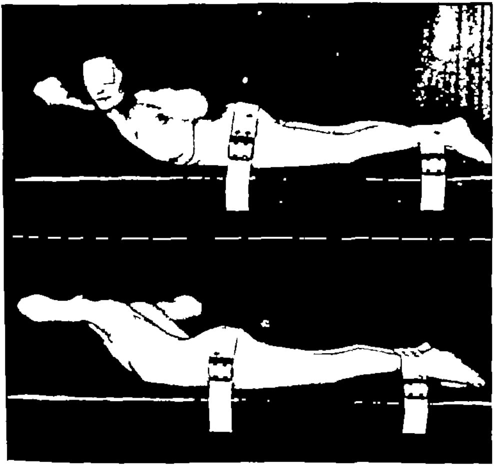


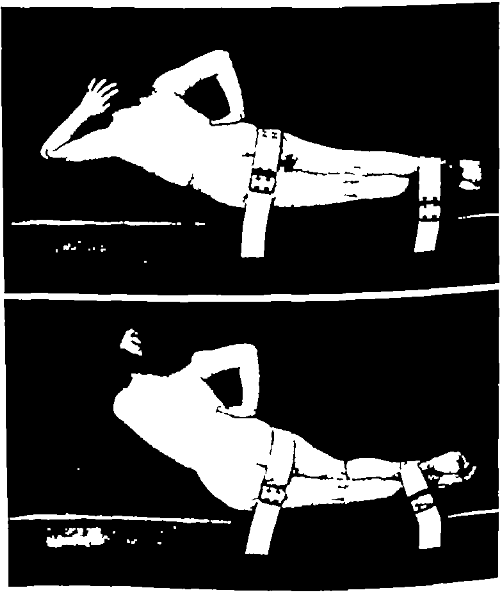
FIG. 6 and 6 —Lateral and rotat training.

thrust of the left upper extremity (Fig 79) and the movement is repeated with progression of crawling

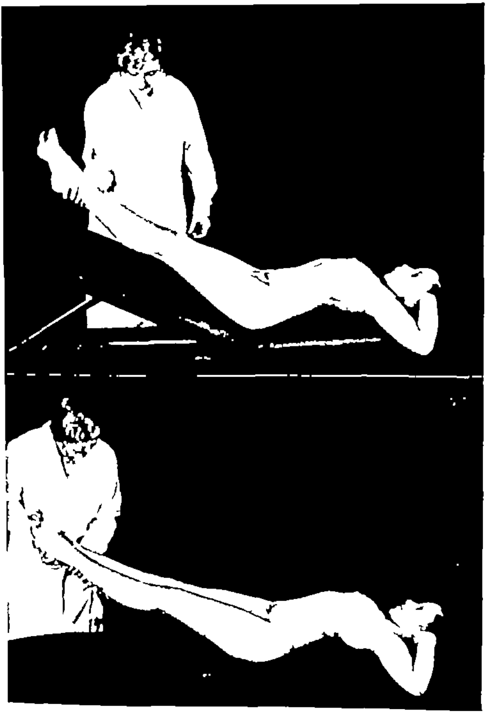
In addition *asymmetric lateral flexion* is performed accompanied by voluntary passive stretching by the patient (Fig. 83) In this the patient voluntarily contracts the muscles on the convex side of the curve while utilizing the upper extremities as levers for passive stretching of the concave side. This is done rhythmically and slowly

hand As an example, a typical decompensated right structural dorsal scoliosis of paralytic origin is shown in Figures 74 and 75 The patient was retained in recumbent head and pelvic traction while Exercises B were carried out in addition to efforts to mobilize the compensatory curves by means of the shifting exercises.

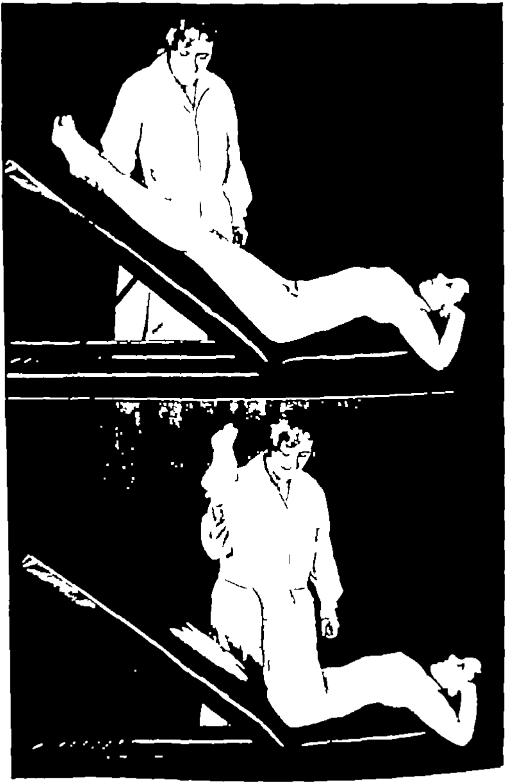
For the *shifting exercises* the patient stands erect with the hands resting firmly upon the pelvis and, by direct downward push with the upper extremities applies upward push upon the trunk to the maximum degree of correction of the curve (Fig 76) While this position is held, the trunk is shifted to the extreme degree to the side opposite the curve (Fig 77) This tends to accentuate compensatory curves and to realign



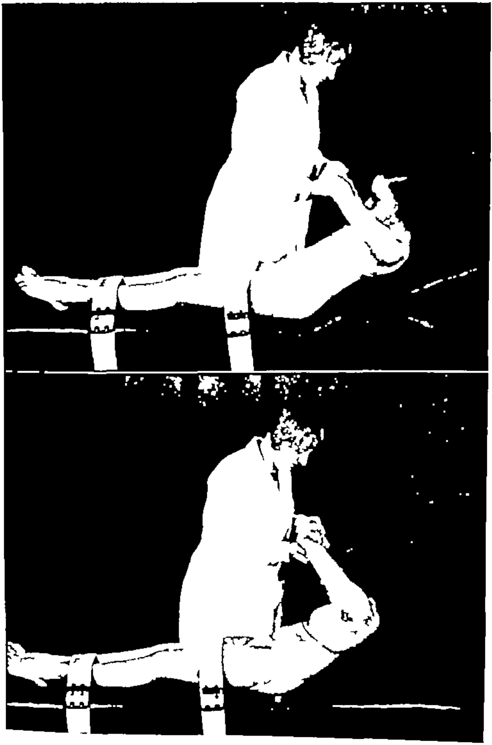
FIGS. 59 and 60—Lateral flexor training.



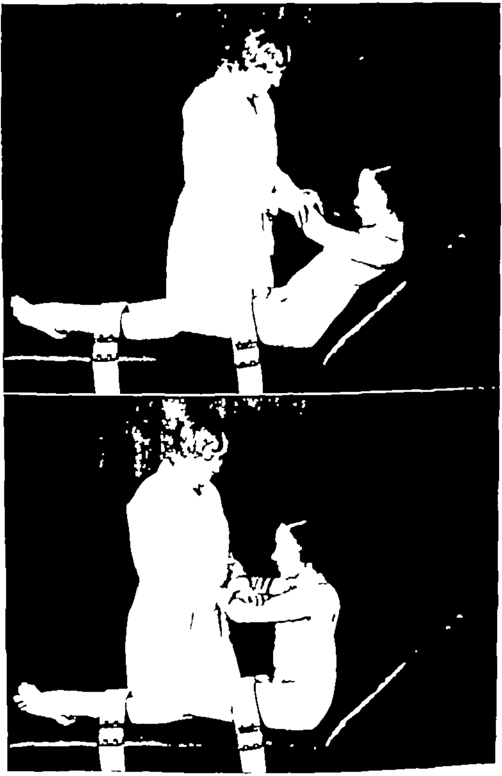
FIGS 65 and 66—Passive aid to flexion, increased range.



Figs 63 and 64.—Passive aid to flexion, limited range.



Figs. 69 and 70.—Passive aid in flexion.



Figs. 67 and 68.—Passive aid in flexion.

knee is flexed rhythmically adding weight to the corrective influence of the traction To these exercises may be added the asymmetric use of any of the general muscle-training exercises outlined in A and B

Passive manipulative procedures.—For the sake of simplicity the numerous mechanical devices for exerting forcible traction and passive movement will not be enumerated They are all based upon the effort to secure hold upon the trunk by fixation of the pelvis and by utilizing the upper extremities and thorax to apply pull rotation and corrective flexion. It is doubtful if complicated apparatus will retain a

Fig 73.—Passive aid in rotation.

place in this field and it certainly never will assume the place of the well-trained devoted physical therapist who intelligently applies the simpler procedures above outlined After all the present knowledge of the subject eliminates the urge forcibly to unbend and untwist a scoliotic curve and it is apparent that the desideratum i.e the compensation can be secured without it and that nothing else can be secured with it. Moreover rapid forcible correction is utterly out of the question therefore all that can be expected of apparatus is to spare the physical labor of the physical therapist. Every movement tending to act in a direction opposite to the tendency of the deformity whether active

A similar influence is exerted by the *standing suspension and abduction exercises* (Fig 84) The left hand grasps the bar in a manner to extend the scoliotic curve by traction while the right lower extremity, aided by the right hand which depresses the right shoulder is gradually and rhythmically abducted Thus the right shoulder and the lower extremity are approximated, and while they are in this position the left

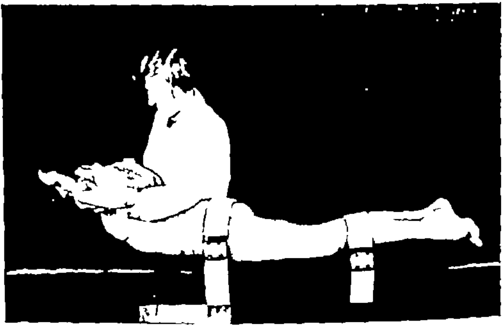
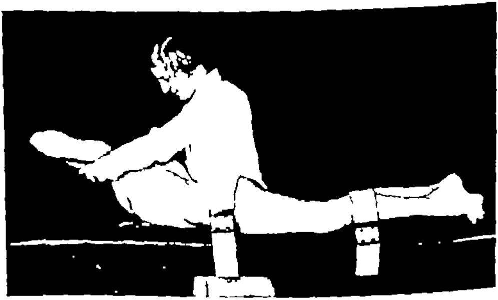


FIG. 71 —Passive aid in extension.



F 7 —Passive id in lateral flexion and extension.

consists merely of a hinged table in which the point of bending may be used as a fulcrum at the summit of the primary curve with the *patient keeping himself in traction by holding on with his hands.*

The model used for this series of exercises (B C D) was subjected to the routine of decompensated scoliosis viz recumbent traction mobilization corrective exercises B C and D the shift plaster spica (Figs 91 and 92) a brace and indefinite continuation of the asym metric muscle training and shift exercises Compensation has been attained to the degree shown in Figures 93 and 94 and will gradually increase. The régime must be continued until the spinal structures mature.

It is justifiable when in doubt as to the necessity of apparatus or of head and pelvic traction to attempt the use of physical therapy alone and to observe the course for there are severely decompensated

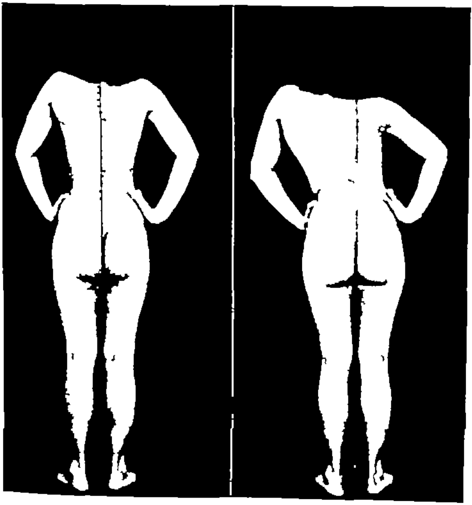


FIG. 76—Shifting exercise. Movement No 1
FIG. 77—Shifting exercise. Movement No. 2.

or passive is capable of oft repeated exertion by the patient and the therapist if there is mutual understanding of the aim.

The simplest and most effective measures of passive ministration are head and pelvic traction in recumbency the shift plaster described, and suspension of the patient by the arms and head. Voluntary stretching while suspended on the rings is illustrated in Figures 85 and 86 The patient hangs on the rings and by rhythmic movements in the position shown in Figure 86, stretches the concave side of the curve and contracts the opposite This may be supplemented by passive application of gravitational traction in the Sayre device (Figs. 87 and 88) These same principles are applicable by means of apparatus counterbalanced by weights, in which the efforts of the operator are exerted with less work, such as the device in Figures 89 and 90 which

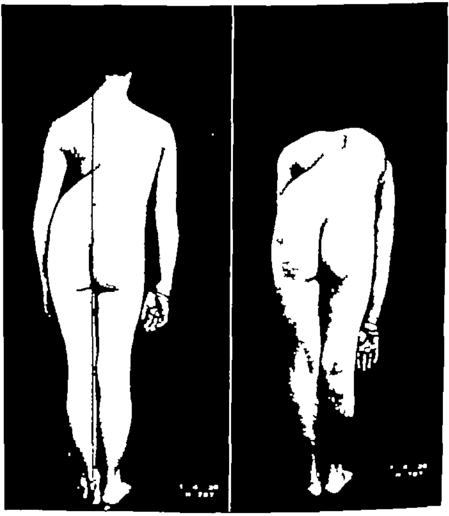
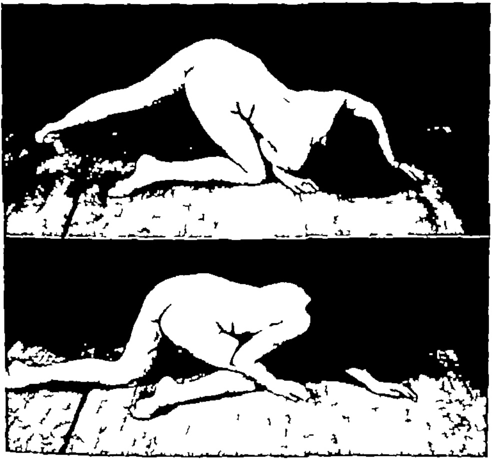


FIG. 74.—Right structural dorsal scoliosis decompensated model for Exercises C.
FIG 75 —Same. In flexion.

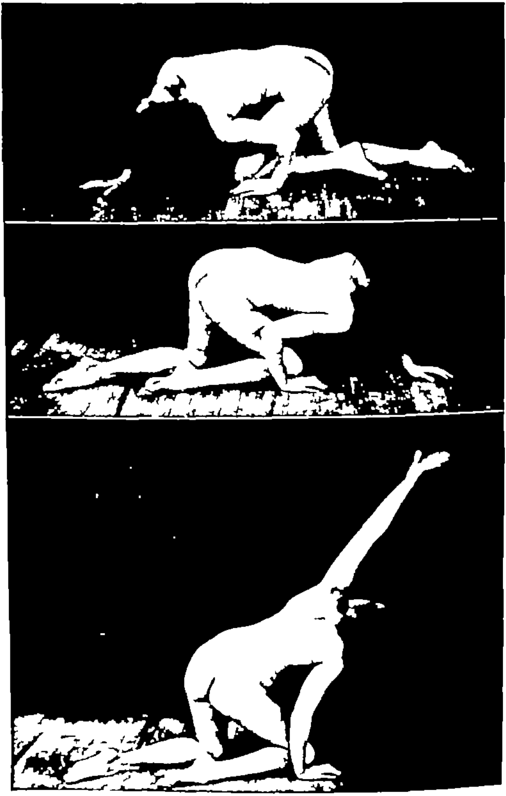
curves that respond readily without the tedium of the longer routine Such an instance is well illustrated in Figures 95 and 96 which depict severe imbalance and list and no effort at compensation. The patient possesses excellent musculature throughout the capacity to shift is shown in Figure 97 and with no other treatment than physical therapy she has attained correction of balance as indicated in Figures 98 and 99



FIGS. 81 and 82—Creeping exercises.

The patient must be impressed with the necessity of indefinite continuation of observation and physical therapeutic work at home.

The mere presence of deformity must not lead the surgeon or therapist into treatment of a stationary curve Figures 100 and 101 exhibit extreme deformity which, without treatment other than a brace maintains equilibrium and compensation and hence should not be interfered with. The patient was not seen for two years when he returned improved (Figs. 102 and 103)



Figs 78 79 and 80—Creeping exercises.

structure directly by operation The maximum correction of the primary curve and the creation of the secondary curves having been attained through the measures hitherto described the bony structures of the spine are exposed and by operative measures converted into a rigid segment either by a bone graft or by plastic bone operation upon the vertebrae Details of the procedure may be found in standard works or orthopedic surgery An instance is illustrated in Figures 109-

Fig 84—Suspension and abduction exercise.

112 wherein in the presence of extreme tendency to decompensation the spine was fused surgically from the sixth dorsal to the second lumbar vertebra with resulting maintenance of stability and alignment In this field, however disappointments and relapses in loss of equilibrium after operative treatment are not uncommon

In Figures 38 to 88 inclusive the seemingly remarkable degree of

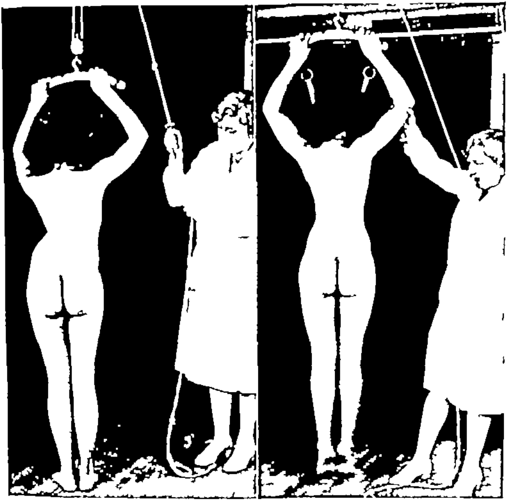
Furthermore, enthusiasm for physical therapeutic measures should not lead the therapist to ignore the effectiveness of measures of external support Indicative of this feature is a case of spastic dystonic scoliosis of severe degree (Fig 104) made worse by any active or passive measures of physical therapy When held in plaster for months (Figs 105 and 106), and later in a brace the scoliosis subsided with decrease in the intensity of muscle hypertonicity to the degree shown in

FIG. 83—Asymmetric lateral flexion aided by voluntary passive stretching.

Figures 107 and 108 If the patient had not been supported artificially this curve would have become irretrievably fixed in decompensation.

Occasionally experience may convince one of the advisability of making the spine stiff by splinting from within" In other words the extrinsic elements upon which reliance must be placed to maintain compensation are undependable This having been determined (and it is a delicate determination) it becomes necessary to attack the skeletal

The impressions given herewith are based upon the writer's experience with approximately 175 cases of scoliosis in the last ten years but they have originated largely in the substantial contributions to the literature on this subject by R W Lovett,[2] Arthur Steindler [3] W Schulthess [4] and others from whose writings I have borrowed



FIGS. 87 and 88—Passive vertical traction.

DORSUM ROTUNDUM (ROUND BACK)

The deformity of the spine incidental to loss of stability from any cause may be confined to anteroposterior deviations In other words there is no lateral curve or torsion.

Any factor causing loss of tonicity of the general musculature or softening of the osseous or cartilaginous structures of the spine tends to result in longitudinal collapse which is followed by pathologic

passive correction of scoliosis by means of vertical traction has been disclosed and one is impressed by the fact that if such a degree of corrective influence could be perpetually exerted, the outlook in general would be better This impression has been corroborated in my experience with those who, because of paralysis of the lower extremities have been obliged to use crutches to such a degree that one might be tempted to designate crutches as one of the most effective means of treating this complex and intractable deformity (Figs 113 114, and 115)

Conclusion —In conclusion, one must not at best regard the prospect in scoliosis with optimism. It is a field which requires all the ingenuity of the surgeon and the physical therapist and is fraught with many disappointments In it more than in any other field perhaps, are teamwork, patience, and pertinacity essential.

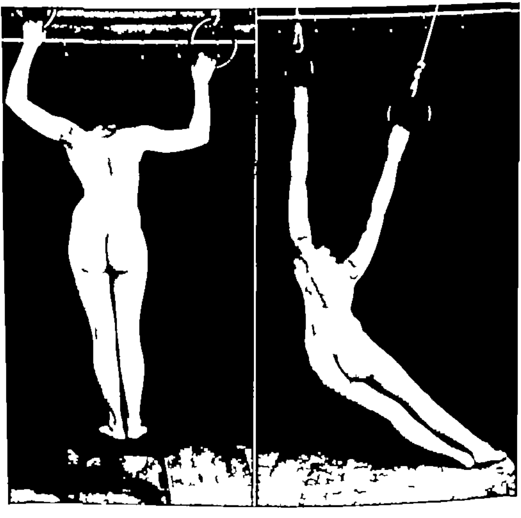


FIG. 85 —Passive voluntary stretching on rings.
FIG 86.—Passive voluntary stretching suspended by the rings.

increase in the physiologic curves Depending upon the nature of the underlying pathology the length of time inflicted, and the treatment accorded the exaggerated curves become more or less fixed This deformity varies in degree from mild postural relaxation which is readily passively corrected to the great rigid round back of chronic arthritis In the aged the thinning of the intervertebral discs creates the general forward bent spine

Since the treatment of postural deformities is found elsewhere I confine the present discussion to round back in children due to changes in the osseocartilaginous structures Such changes are in the nature of malacic phenomena secondary to either general or local factors Moreover the changes may be general throughout the spine or limited to certain areas thereof

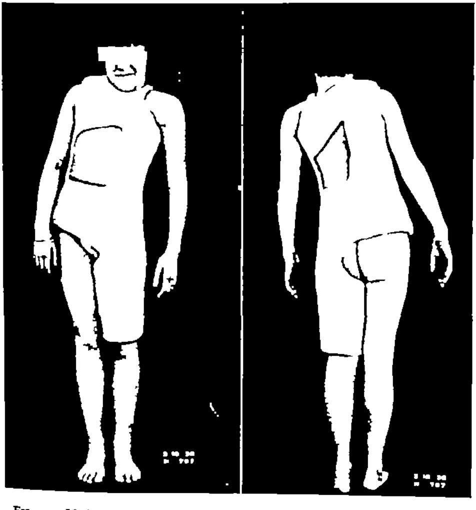
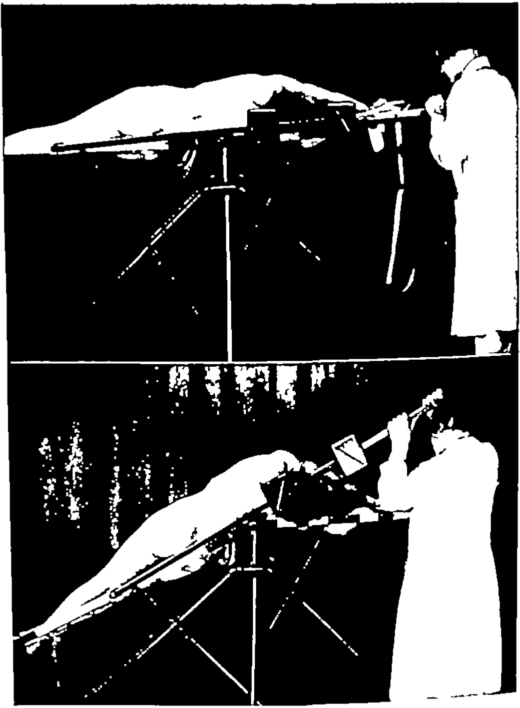


FIG. 91.—Model after application of shift plaster spica.
FIG. 9 —Posterior view of same.



FIGS. 89 and 90.—Traction and passive movement by means of counterbalanced hinged table.

2 Limited portion of the spine
  a. Localized epiphysitis
  b Localized arthritis
  c. Localized trauma (fracture)

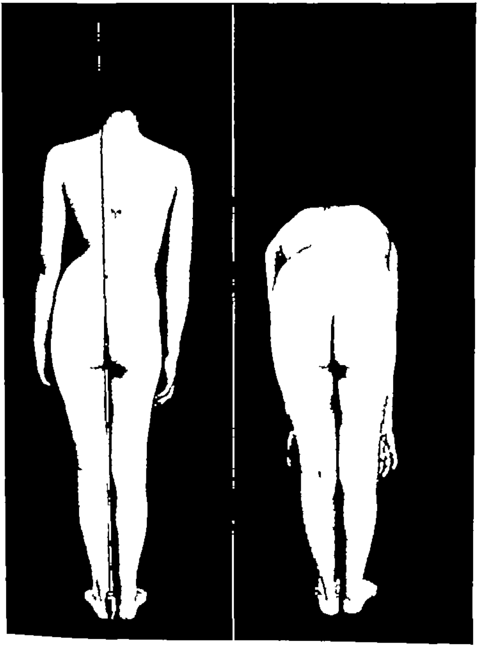


FIG. 95—Decompensation, lumbodorsal right structural scoliosis.
FIG. 96.—Same as Fig 95, flexed.

Etiology —The etiology of fixed round back may be summarized as follows

1 Malformation of vertebrae or cartilages due to
   a. General skeletal disease
      1 Rickets
      2 Chondrodystrophy
      3 Osteomalacia
   b Skeletal disease affecting the spine alone
      1 The entire spine
         a. Osteochondritis
         b Arthritis
         c. Absorption of cartilage in the aged

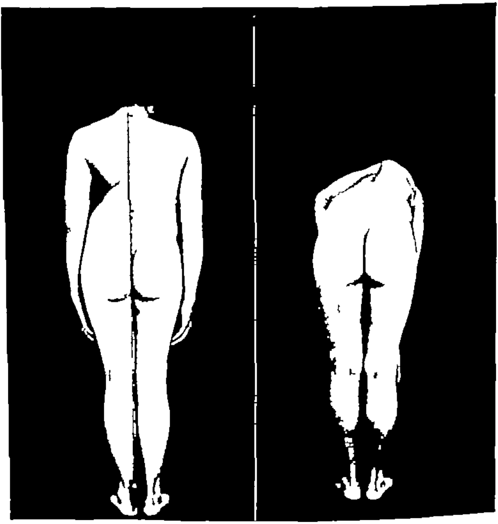


FIG. 93 —Model one year after beginning treatment Acquisition of compensation and maintenance therapy

FIG 94 —Same as Fig. 93 flexed.

Moreover the general symmetrical exercises for trunk and spinal musculature should be instituted as early as the coöperation of the patient can be secured

At a later period in life i e in the second decade most commonly in girls at the age of 14 to 17 there occurs the common form of "round shoulders or round back the result of asthenia of any form and static in origin. It may be readily corrected passively and the treatment consists of posture training symmetrical muscle training and in intractable types of a brace, as described under "Scoliosis (Fig 33) In those in whom forward rotation of the shoulders appears to be the chief element of deformity a simple shoulder strap may suffice (Fig 116) The outlook in the static form if exercises and training are persistent is good for the ultimate correction of the tendency

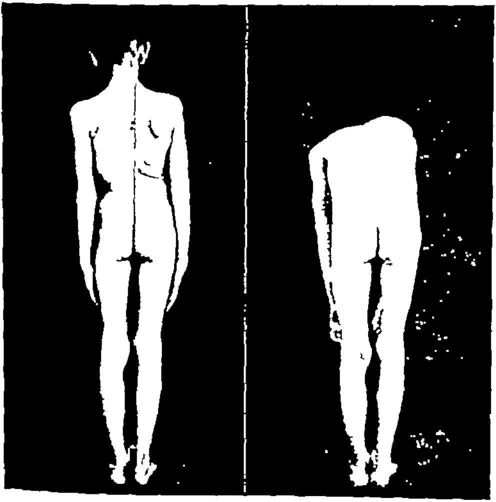


FIG. oo—Marked def rmity structural, treated with brace only
FIG. 10 —Same as Fig. oo, flexed.

d Tuberculosis
e. Congenital malformation of the vertebrae

In infancy there is little or no physiologic lordosis in the lumbar region This is acquired gradually as sitting up is acquired, and is increased upon standing and walking But in infancy, if the child is rachitic or if there is general muscular atony the back is inclined to assume an attitude of general backward curve in other words the whole trunk has 'slumped" forward To prevent such a deformity from becoming confirmed, it is better to discourage sitting until general rachitic treatment has improved the underlying factor In such cases a light corset reënforced posteriorly to support the usually pendulous abdomen and to maintain the spine erect should be worn and upon walking the light brace illustrated in the section on scoliosis (Figs 32 and 33) should be utilized

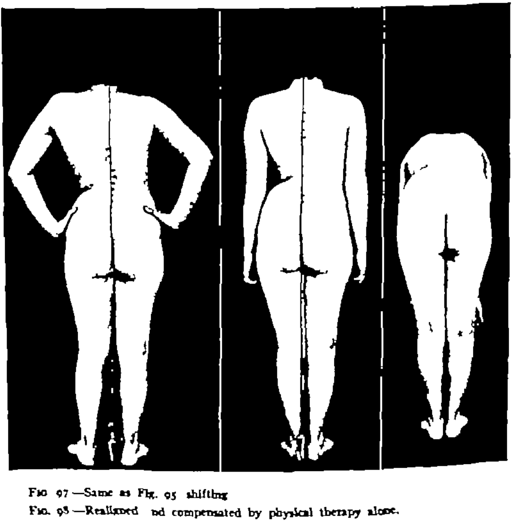


Fig 97—Same as Fig. 95 shifting
Fig. 98—Realigned and compensated by physical therapy alone.
Fig 99—Same as Fig. 98 flexed.

chest is deep, but the muscles are strong and no disability results in girls more often the patient becomes asthenic and goes through life in semi-invalidism when untreated.

This entity is evidently the result of an atypical or pathologic process of ossification of the epiphyses of the bodies of the vertebrae In the growth of the longitudinal thickness of each vertebra there appears at the upper and lower articular surfaces a disc of bony ossification which is first noted at the age of 13 or 14 This disc gradually increases in thickness and unites when the individual is at the age of

Fig. 94—Scoliosis due to dystonia musculorum.

22 or 23 or when the body completes its growth In those children developing the above-described deformity these discs become irregular and sometimes fragmented suggesting the nature of the changes seen in the growing femoral capital epiphyses in Legg's (Perthes) disease and the carpal navicular in Koehler's disease. Even untreated ossification goes on and is ultimately completed but the result is the unalterably fixed round back. Early in the disease there is sufficient resiliency to enable correction, which however becomes progressively more re-

Much more difficult is the dorsum rotundum in children of this same age which has as its origin a disorder of the growth of the vertebrae The back gradually and painlessly assumes the attitude of excessive convexity of the dorsal spine and this convexity is fixed i e., cannot be passively or actively corrected The head is thrust forward and in a compensatory effort to maintain balance the lumbar curve becomes accentuated. Thus there is the picture of round back above and sway back' or hollow back below (Figs. 117 and 118) The shoulders are narrow and the abdomen sags Thus there is assumed the habitus ptoticus' with flattening of the chest, descent of the diaphragm, limitation of respiratory excursion and abdominal visceral ptosis with its train of disorders Not uncommonly in boys the disorder becomes arrested, the back remains round and fixed and the

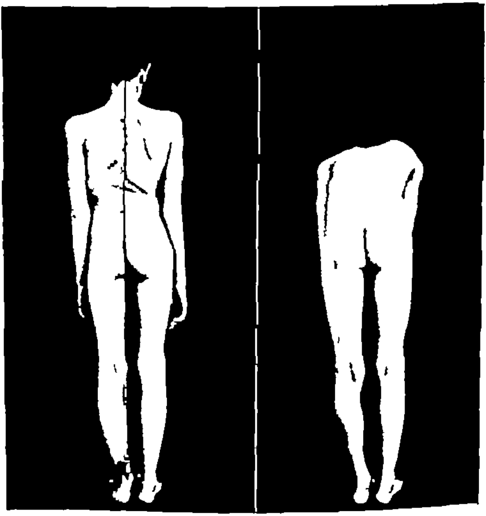
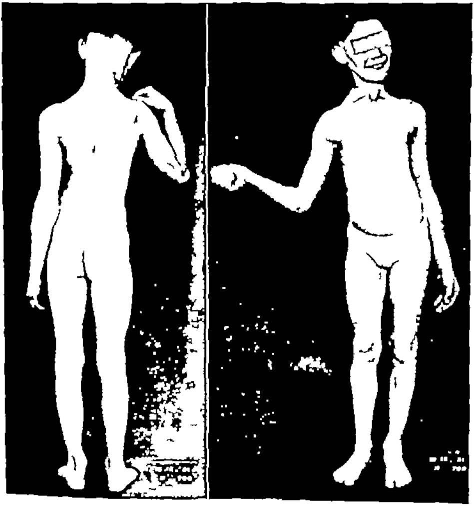


FIG. 102—Same as Fig 00. After 2 years with brace only Compensated with little or no treatment

FIG. 1 3—Same as Fig 0 flexed.

c. Later muscle training
d. General treatment of underlying cause
e. Radiation violet rays

2. In adolescence
   Congenital
   Static
   Postural
   a. Symmetrical muscle training
   b. Swimming
   c. Corset, brace or shoulder straps
   Osteochondritic
   a. Same as a, b and c under 1
   b. Recumbency and traction if needed
   c. Special passive and active exercises

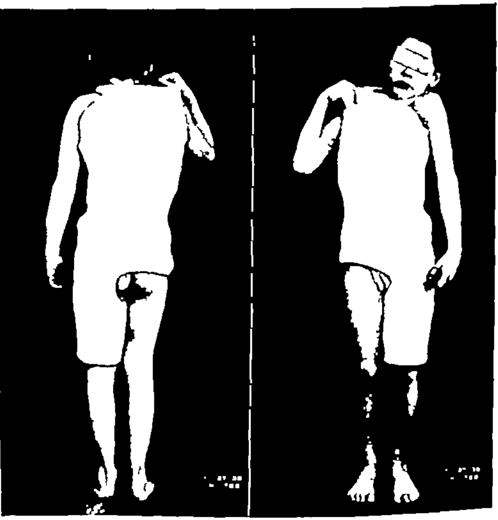


FIGS. 97 and 98.—Same as Fig. 96 after subsidence of dystonia musculorum.

sistant with time. It would appear that this pathology may be rather acute in its onset, causing pain in the back, fatigue on little exertion, and sometimes pain on movement, and it may thus be confused with early tuberculosis or other disease On the other hand, it may be of such gradual development as to be unnoticed except for the deformity Moreover, it may be diffuse, affecting all the spinal elements, or it may be localized in two or three vertebrae In the former deformity will be general, in the latter it may be angular to the degree of localized gibbus.

Treatment.—This may be epitomized as follows

1 In infancy
   Rachitic
   Amyotonic
      a. Recumbency
      b Corset supports



Figs. 05 and 106—Same as Fig. 104, In plaster

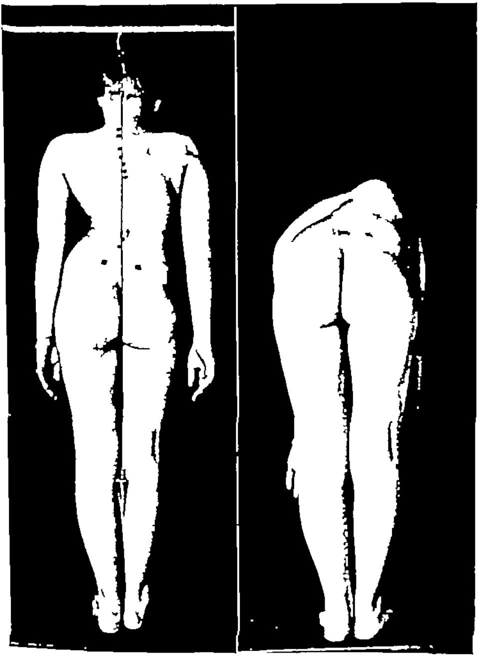


Fig. 1—Same as Fig. 110, after operative fusio f the spine.
Fig. 112—Same as Fig flexed

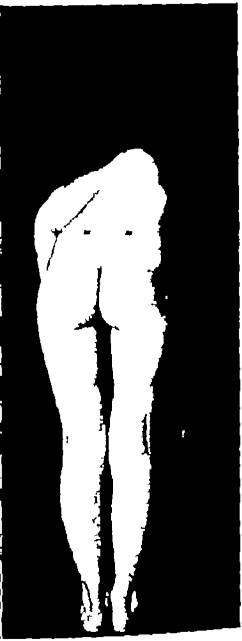


Fig. 109—Broken compensation. Severe right structural dorsolumbar scoliosis. Relapsed after conservative treatment. Incapable of retention. Suitable for fusion.

Fig. 110.—Same as Fig. 109 flexed.

Recumbency and traction having corrected the deformity the problem is to maintain it. This is accomplished by braces of the types illustrated (Figs 32 33)

Muscle Training —In the case without pain which is the usual type the treatment consists of general muscle training of spine and trunk and special active and passive corrective procedures The régime is directed toward the reëstablishment of general muscle tone and hence support passive correction of the posterior convexity of the dorsal spine and anterior convexity of the lumbar spine, and incidentally retraction of the abdomen and elevation of the diaphragm and expansion of the chest. The passive corrective procedures are really applied under the physical therapist s direction by the patient

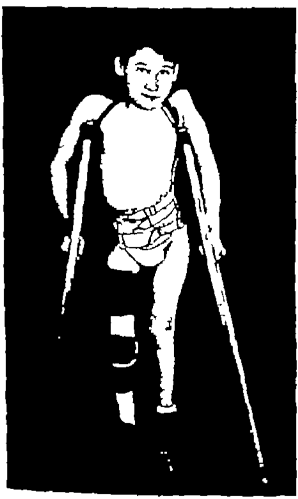


Fig. 115.—Same as Figs. 113 and 114. Striking corrective influence of crutches.

Fig. 116.—Simple shoulder apparatus in round shoulders.

3 In adults
   Arthritic
   Traumatic
      a. Recumbency in Bradford frame, plaster dressing traction
      b Brace
      c After quiescence, heat massage, muscle training

Tuberculosis and other infections causing deformity are discussed elsewhere. Herewith is treated only the dorsum rotundum of adolescence due to vertebral disorder of growth referred to above. The principles are the same as in any anteroposterior deformity of the

FIG. 113.—Marked attitudinal and paralytic scoliosis.
FIG. 114.—Same as Fig. 113 from behind.

spine. First of all if pain is present all procedures involving movement, either active or passive, are contraindicated. Second if pain is absent but is caused by movement, the latter is contraindicated. Third if pain is absent on active or passive movement then movements both active and passive are essential in the treatment.

RECUMBENCY AND TRACTION —In the presence of round back with pain tenderness or instability primary treatment consists of recumbency on the Bradford frame with head and pelvic traction (Fig. 47) Thus can deformity be gradually and painlessly corrected and quiescence of the painful element can be encouraged

himself and are therefore not purely passive but are the more effective for that reason The useful procedures for the purpose are as follows

1 *Direct Vertical Traction on the Rings Accompanied by Swinging* This elevates the shoulders flattens the abdomen pulls upon the chest wall through the thoracicohumeral musculature, and tends to exert traction on the round back (Fig 119)

2 *Standing Backward Shoulder Stretching* The patient, standing in a corner with hands applied to walls bends forward and pushes forward with lower extremities This pushes the shoulders backward upon the thorax and expands the chest anteriorly (Figs 120 and 121)

3 *Recumbent Stretching on Roll under Round Back* A thick felt pad or roll is placed beneath the dorsal spine with arms behind the head Arms and head above and trunk below exert leverage upon the dorsum rotundum as the fulcrum (Fig 122)

FIG. 119.—Round back exercises. Hanging and swinging on the rings.

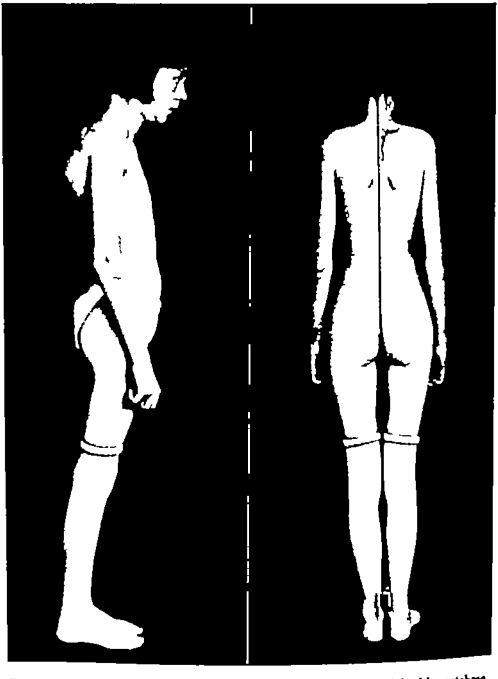


Fig 17—Dorsum rotundum due t osteochondritis vertebrae or epiphysitis vertebrae
Fig 118—Same as Fig. 117 posterior view

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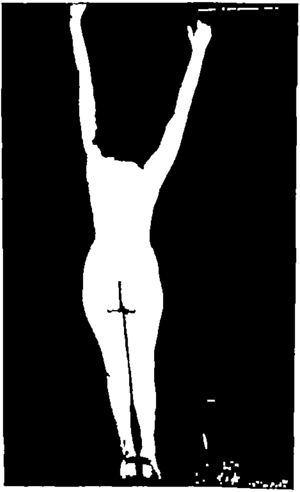

Fig. 119.—Round back exercises. Hanging and swinging on the rings.

4 *Abdominal Retraction* With the same position as in "3" the abdominal musculature is retracted sufficiently to flatten the lumbar curve This exercises the abdominal muscles expands the chest, and increases the leverage on the dorsal spine (Fig 123)

5 *Dorsal Flexion against Round Back* In the prone position with the strap applied over the summit of the dorsal curve, head and shoulders are actively dorsiflexed, thus exerting passive corrective influence on round back and strengthening the extensor musculature (Fig 124)

6 *Standing Table Exercise* The patient stands forward flexed at hips, with trunk upon a table arms extended above, grasping a staff While maintaining contact between abdomen and table, arms are extended with staff over the head, staff is brought into contact with round dorsal spine, and backward leverage is exerted by further extension of curved dorsal spine Thus the lumbar curve is flattened, the

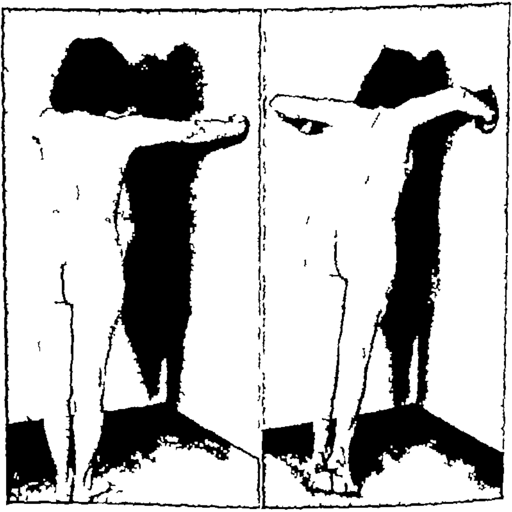

Fig 120 and 121 —Standing stretching shoulders backward.

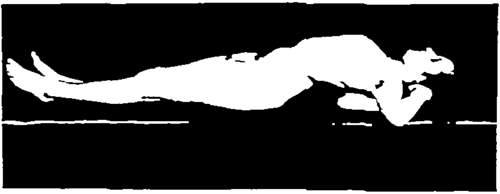

Fig. 122.—Recumbent, stretching on roll under round back.

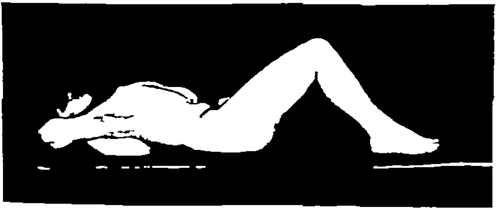

Fig. 123.—Abdominal retraction.

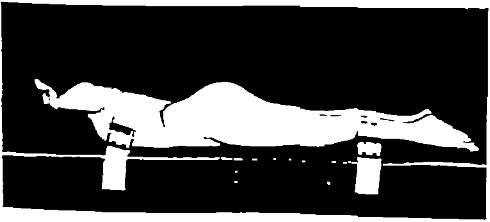

Fig. 124.—Dorsal flexion against round back.

4 Abdominal Retraction With the same position as in "3" the abdominal musculature is retracted sufficiently to flatten the lumbar curve This exercises the abdominal muscles expands the chest, and increases the leverage on the dorsal spine (Fig 123)

5 Dorsal Flexion against Round Back In the prone position with the strap applied over the summit of the dorsal curve head and shoulders are actively dorsiflexed thus exerting passive corrective influence on round back and strengthening the extensor musculature (Fig 124)

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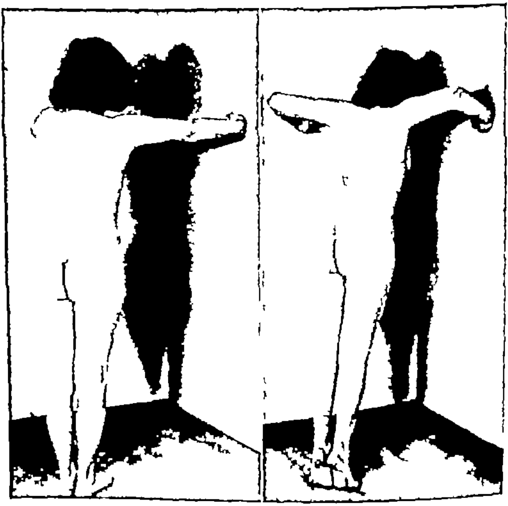


Fig o and —Standing stretching shoulders backward.

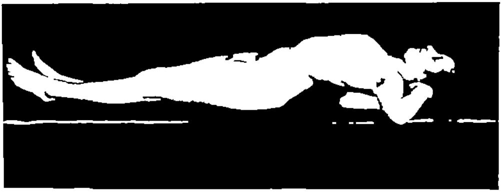


Fig. 122.—Recumbent stretching on roll under round back.

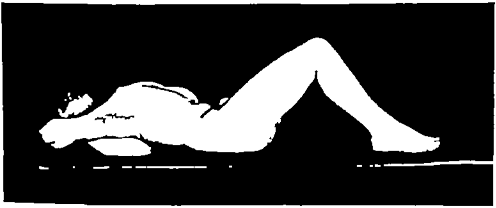


Fig. 123.—Abdominal retraction.

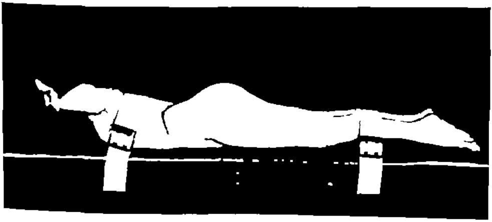
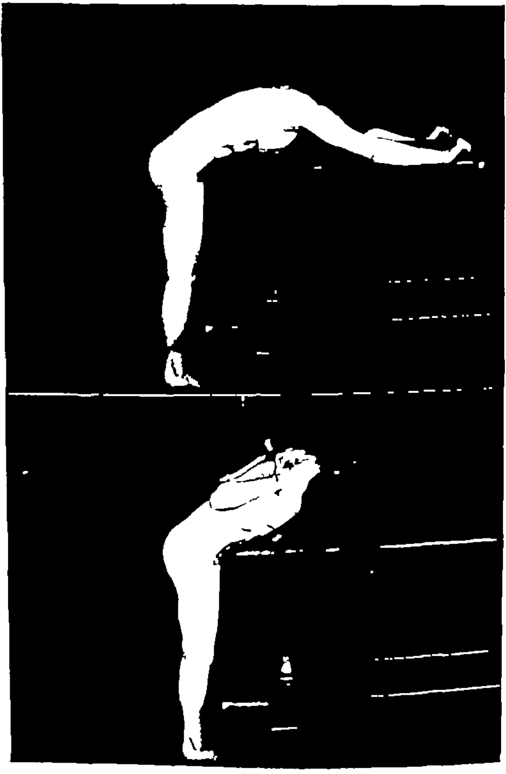


Fig. 124.—Dorsal flexion against round back.



Figs. 5 and 6—Standing table exercise

dorsal curve is decreased and the spinal musculature is strengthened (Figs 125 and 126)

All these exercises are to be carried out slowly and gracefully within the limits short of fatigue and they are supplemented by swimming and general calisthenics They are simple enough to enable the patient to learn the routine and to carry them out at home twice daily Moreover, the child must be impressed with the necessity of maintaining the attitude of maximum correction at all times and when he is unable to do so, this effort must be supplemented by apparatus

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CHAPTER EIGHTEEN

TREATMENT OF MALIGNANCIES OF THE SKIN

George M MacKee M D and Anthony C Cipollaro M D

CANCER OF THE SKIN AND ORIFICIAL MUCOUS MEMBRANES

Foreword

Throughout this chapter the various physical agents used for the treatment of cancer of the skin and orificial mucous membranes and for the treatment of conditions that might lead to cancer are mentioned but are not described A detailed description of these methods and agents is given in Chapter 18 Volume I and Chapter 4 Volume III. Technical details contained in those chapters are not repeated here Also many terms are used in this chapter for which no definition is given. Explanations for these terms are contained in the chapters mentioned above

The family physician for whom this chapter is written is often the first to be consulted by a patient who has cancer or who has a condition that may lead to cancer It is important therefore for the practitioner of general medicine to be well acquainted with the clinical aspects of these conditions Many general physicians are excellent surgeons using either the scalpel or surgical diathermy or both. Only experts in the use of roentgen rays and radium are qualified to use these agents in the treatment of cancer but every physician should know what is being accomplished with these agents

For the reasons enumerated above considerable attention is given to clinical description and to therapeutic methods that are employed by physicians other than specialists A few statistics are included. The discussion of roentgen ray and radium therapy in relation to the cancer problem is general. This discussion gives information with which the family physician should be familiar It must not be construed as an attempt to teach the technic of such therapy nor to encourage the use of these agents by general physicians The bibliography contains references for those who are particularly interested in roentgen ray and radium treatment.

Mortality and Incidence of Cutaneous Cancer

The incidence and death rate of cancer increased markedly in New York City between the years 1910 and 1930 Statistics for New York City may be taken as a barometer for other large urban centers in the United States Several factors are apparently responsible for this increase, the most important being the longer expectancy of life. Cancer is most prevalent after the age of 40, and a much larger proportion of the population now reach the later decades than was formerly the case Improved methods of diagnosis, cancer propaganda and education (directed at both the medical and lay public), and better statistics are other factors which influence the incidence and death rate.

The death rate can be ascertained with a fair degree of accuracy In New York City the death rate from cancer was 78 per 100,000 of population in 1910 In 1930 the rate had increased to 117 per 100 000 population The actual number of deaths from cancer in New York City during the year 1930 was 8 025 [1]

When cancer as a cause of death in New York City is compared with other diseases it is found to rank second to heart disease to equal pneumonia and to be far above tuberculosis Succinctly the death rate per 100 000 population for heart disease (for 1930) was 244 for cancer, 117 for pneumonia, 116 for tuberculosis 64.

Of the total of 8 025 cases of cancer that terminated fatally and appeared on the death certificate as the cause of death in New York City in 1930, 363 (4 52 per cent) were cancers of the skin and buccal cavity The tumors in these 363 patients were located as follows cancer of the buccal cavity—males, 229 females 28 (3.20 per cent) Cancer of the skin—males 66 females 40 (1 32 per cent)

In the registration area of the United States there were 76,274 deaths from cancer and other malignant tumors (mostly cancer) in 1921 Of these 2 610 (3.42 per cent) were cancers of the mouth, 2 132 occurring in males and 478 in females Two hundred and eighty seven deaths (0 38 per cent) were due to cancer of the vagina and vulva. Malignancy of the skin was given as the cause of death in 2,433 cases or 3 19 per cent

Since cancer is not a reportable disease, it is impossible accurately to determine its incidence Also at the present writing it is impossible to ascertain the total number of cases of cancer of the skin and orificial mucous membranes that have been cured

The point to be emphasized here is that approximately 7 per cent of deaths due to cancer in the United States (1921 statistics) are caused by cancer of the skin and orificial mucous membranes. In one year (1930) there were 363 deaths in New York City caused by cancer of these parts

As we shall see later the therapeutic results in cases of advanced metastatic cancer are encouraging in certain morphologic and cytologic types of such growths the results are excellent. However, there is

no certain cure for unselected cases of advanced cancer hence the large mortality Cancer in a very early stage of evolution before metastasis has occurred is usually curable Obviously, therefore if every case of cancer could be diagnosed sufficiently early and adequate treatment immediately instituted there would be a spectacular drop in cancer fatalities Such a desirable attainment is very often impossible in the case of cancer of the viscera and other deep structures But it is possible in the majority of cases of cancer of the skin and orificial mucous membranes. It is even possible to accomplish more than this Many cutaneous cancers develop as a result of a long standing antecedent lesion These potentially dangerous lesions are well known and will be described later Most of them can be permanently eradicated. If all or the majority of such conditions were recognized and destroyed there would be a substantial reduction in cancer incidence.

The dermatologist can usually make a clinical diagnosis of early cutaneous cancer and of conditions that may lead to cancer When this is impossible a microscopic examination may help to establish the diagnosis The practitioner of general medicine cannot be expected to make all the necessary clinical differentiations between cancer or dangerous cutaneous lesions and the large number of benign conditions which they may simulate. Proper undergraduate and postgraduate instruction in dermatology with sufficient emphasis on the conditions under consideration will increase the diagnostic ability of the physician Periodic health examinations will give the family physician opportunity to examine the entire cutaneous surface and the membranes of the orifices The family physician really should be able at least to detect dangerous lesions of the skin and membranes and to suspect the potentialities He may then request a consultation or microscopic examination, or eradicate the condition according to his training ability facilities and willingness to assume responsibility

When dealing with malignant growths or conditions that may lead to such growths the situation is so serious—i.e. it is so essential that no diagnostic or therapeutic error be made—that it seems advisable for the family physician to request a division of responsibility

In recent years several organizations have conducted a determined and comprehensive campaign of cancer education in an attempt to reduce the incidence and mortality of the disease. This campaign has undoubtedly accomplished a great deal of good It is probable that a continuation of the cancer propaganda directed at the lay public will prove helpful especially if very carefully done It seems advisable to teach the public, with carefully selected words that cancer is amenable to treatment and that it is often preventable Rather than attempting to teach symptomatology which so often proves injurious it seems preferable constantly to urge periodic health examinations These organizations can help to educate the medical public by continuing to suggest adequate instruction for the undergraduate medical student

and suitable postgraduate courses, seminars symposiums, addresses, articles, monographs and books for the practicing physician.

Cutaneous Conditions That May Give Rise to Cancer

The lesions and conditions of the skin and orificial membranes that frequently and occasionally give rise to cancer are known as the precancerous dermatoses The term is a poor one because it implies a necessary sequence, whereas in reality even the most dangerous members of the group do not always give rise to cancer and many of the so-called precancerous dermatoses are hardly more dangerous than is normal skin There are pathologists dermatologists and cancer experts who aver that there is always a precancerous stage to every cancer Often the precancerous condition is visible to the naked eye. At times it can be detected only with the aid of a microscope. In support of this contention are the so-called nonpigmented melanomas which have been shown to arise in defects that are not macroscopic, also the so-called nevus tardus—a birth mark which presumably must be present at birth but which does not become visible for weeks, months or many years after birth.

Without delving deeper into the academic aspect of this controversial subject, suffice it to say that dermatologists employ the term *precancerous dermatoses* simply for a convenient sobriquet for a certain group of conditions for purposes of conversation and teaching When teaching medical students or addressing a medical group the exact meaning or significance of the term is explained.

As indicated above the precancerous dermatoses include conditions that frequently give rise to epidermoid carcinoma, either spontaneously or as a result of irritation Among such conditions are leukoplakia kraurosis vulvae senile keratosis certain roentgen-ray and radium injuries the blue-black mole and so on At the other extreme are relatively benign conditions such as a long-standing ulcer, a large scar and a large number of cutaneous lesions. Any permanent elevation above the normal surface of the skin such as a small scar a common mole or even a wart, if frequently irritated or traumatized as might happen on the bearded region of an adult male might lead to cancer An area of gum constantly irritated over a period of many years by a ragged tooth might also give rise to cancer Such conditions are comparatively free but not entirely free of danger It is for this reason that these and many other more or less similar conditions are included in the group of precancerous dermatoses

Alphabetical List of Forerunners of Cutaneous Cancer

Cicatrix
Cornu cutaneum
Erythroplasia

Farmers skin (sailors skin)
Inflammatory dermatoses

Eczema
Lichen planus
Psoriasis

Keratoses

Arsenical
Seborrheic
Senile
Occupational

Tar pitch oil carbon etc.

Kraurosis vulvae
Leukoplakia
Lupus erythematosus
Lupus vulgaris
Nevi
Papilloma of tongue
Radiodermatitis
Sebaceous cyst
Syphilis (syphilitic leukoplakia smooth atrophy and interstitial glossitis)
Ulcers (long standing)
Von Recklinghausen s disease (multiple neurofibromatosis)
Xeroderma pigmentosum

Paget s disease and Bowen s precancerous dermatosis have heretofore been included among the precancerous dermatoses They are excluded here because Pautrier [2] Massia and Rousset [3] Fraser [4] and many others who have made careful studies of these conditions find that they are cancer from the beginning Massia and Rousset state that 'One is forced to the hypothesis that both affections are cancerous from the beginning and that their origin cannot be other than in the epithelium of the skin or the deml mucosae in such regions as the nipples, glands vulva, anus, axilla etc The subject is under controversy but the majority of those who have investigated the two diseases agree with the opinion expressed by Massia and Rousset.

CICATRIX

Cancer not infrequently develops in scar tissue, especially in large scars resulting from extensive third degree burns, destructive diseases such as syphilis and tuberculosis, and severe injuries Small scars, even when keloidal or hyperplastic are not considered dangerous unless frequently traumatized The new growth may be sarcoma, but it is

Fig. 1—Squamous-cell epithelioma developing in a scar

usually epithelioma of the squamous-cell variety Epithelioma when developing in scar tissue usually evolves slowly probably because of the dense sclerotic tissue But when the growth invades normal tissue it is apt to be rapidly invasive and metastasis soon occurs. Cancer occurring in scars from burns used to be called Marjolin's ulcer

Small slightly elevated scars that are frequently traumatized may be excised and primary union obtained. If there is a keloidal idiosyncrasy hyperplas i can often be prevented by the postoperative applica

tion of roentgen rays or radium. At times the elevated scar can be reduced to the level of normal skin with these agents without resorting to surgery or the elevated portion may be removed with surgical diathermy especially with a loop electrode, radium and roentgen rays being used subsequently to prevent hyperplasia We are discussing small elevated scars such as may occur on the bearded region of the male adult and which may be cut frequently with the razor Such scars when not subjected to frequent irritation or traumatism over a long period of time are probably no more dangerous than is normal skin. Any or all of the therapeutic procedures mentioned above may fail In such a case the lesion may be therapeutically neglected and inspected once or twice yearly or a plastic operation may be performed

Large scars should be inspected by the family physician at least once a year or the patient should be instructed to consult his physician in case there is any change in the scar Ulcers either spontaneous or traumatic, which occur in scar tissue and which do not heal in a few weeks under the influence of conventional treatment should from a clinical standpoint be regarded as the possible early stage of cancer In such instances it is well to make a microscopic examination. Even without proof of cancer when the ulcer refuses to respond favorably to the various kinds of medicinal and physical therapy remedies recommended for chronic ulcers it seems preferable to perform a plastic operation and remove the danger

CORNU CUTANEUM (CORNU HUMANUM)

The hypertrophy known as the cutaneous horn was so named because of a faint resemblance to the horns of cattle Usually the condition is classified with the keratoses and warts The pathologic change, however is not always that of a keratosis or of a wart. At times the arrangement of cells suggests a corn Like the senile keratoses the cutaneous horn is encountered most frequently in the later decades of life, but it is seen occasionally in children

Cutaneous horns occur most frequently on the face and scalp less frequently on the penis scrotum buttocks and other parts They are usually single. In shape they may be conical cylindric, straight, twisted angular or otherwise They may be of almost any color most commonly yellowish-brown or brownish-black They may be short or several inches in length. In size they vary from a tiny lesion suggestive of a filiform wart to one having a circumference of 14 inches as reported by Rodriguez.[7] The base of the lesion is usually verrucous the greater part of the lesion is composed of keratin. Occasionally they shed spontaneously never to return recurrence however is the rule Lebert[8] estimates that about 12 per cent of cutaneous horns change to cancer

It is advisable to destroy cutaneous horns Small lesions may be extirpated after being softened with a 10 per cent solution of caustic

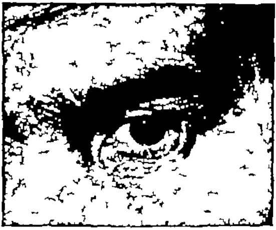

FIG. 1 —Cutaneous horn.

potash Trichloracetic acid may then be applied to the base. A more certain and more popular method of destruction is with electrodesiccation When carefully done the result is permanent and there is either no scar or one that is inconspicuous When preferred the lesion may be excised Solid carbon dioxide, radium and roentgen rays have been employed with good results by some.

ERYTHROPLASIA

(*Épithéliome papillaire nu*)

Erythroplasia is an uncommon affection It was first described by Fournier and Darier [9] in 1893 Queyrat [44] made a careful study of this condition in 1910 and since then in this country the affection has been known as erythroplasia of Queyrat. Sulzberger and Satenstein [49] reported the first American case.

The affection attacks especially the glans penis but may also occur on the orificial mucous membranes At first there may be one or several small lesions which gradually extend peripherally At first only hyperemia may be visible with little edema thickening or elevation Later there develops definite infiltration. The surface is shiny or velvety and there may or may not be a serous exudate Stinging and itching may be present.

Erythroplasia can be considered as a true precancerosis, since in every instance when the patient has been observed for a sufficiently long time prickle-cell epithelioma with involvement of the lymph nodes has developed The disease is likely to be mistaken for eczema, syphilis, epithelioma moniliasis psoriasis and tuberculosis

The etiology is unknown and the histology shows at first acanthosis hyperkeratosis parakeratosis and inflammatory changes Later dyskeratotic changes of a Bowenoid type occur and eventually infiltrating prickle-cell epithelioma develops.

Treatment consists in complete destruction of the lesions by scalpel or electrosurgery Amputation of the penis is necessary in some cases Topical remedies x rays and radium have failed

INFLAMMATORY DERMATOSES

It has been reported that several of the inflammatory dermatoses such as eczema, psoriasis and lichen planus have become carcinomatous The consensus of opinion among dermatologists however is that the neoplasm develops secondary to a keratosis caused by radiodermatitis or arsenotherapy or both It is improbable that these dermatoses per se ever give rise to cancer except perhaps in the case of long-standing lichen planus of the mouth Saad[*] reports a case of buccal lichen planus of three years duration in which carcinoma developed

FARMERS SKIN (SAILORS SKIN)

This condition occurs on the exposed parts of middle-aged and elderly persons who have been exposed to the sun for many years

FIG. 1.—Farmers' skin (sailors' skin) showing atrophy "permanent freckles, senile keratoses and a squamous-cell epithelioma.

and who have a low actinic toleration The skin becomes wrinkled and dry permanent lentigo (freckles) and keratoses develop The condition bears some resemblance to chronic radiodermatitis senile

skin, and xeroderma pigmentosum It is quite common for epithelioma to develop in farmers' skin The epithelioma may be of the basal-cell or squamous-cell type. Squamous-cell growths, when occurring in such skin are often of comparatively low malignancy The present fad for sun bathing and the use of sources of intense ultraviolet radiation in the home may possibly cause a numerical increase of cases of farmers' skin in the future.

Treatment consists of avoiding direct and strongly reflected sunlight or adequate protection against such light. Protection may be obtained by the use of a walnut stain, or by rubbing a dark-colored cream into the skin followed by the application of a dark-colored powder

℞	Ichthyol	gr v
	Carmine	gr ss
	Burnt sugar	ʒss
	Zinc oxide	ʒii
	Starch (rice)	ʒiii
	Vaselin (white)	℥i
	Lanolin	ʒiii

M. Sig Apply to exposed parts for protection against sunlight.

℞	Cosmetic brown	gr viii to xv
	Lanolin, anhydrous	ʒii
	Zinc oxide	ʒi
	Bismuth subcarbonate	ʒii
	Magnesium carbonate	ʒss
	Talc	ʒss
	Starch (rice)	ʒii

M. and pass through fine sieve.
Sig. Apply to exposed parts after using the cream.

An ointment consisting of equal parts vaselin and lanolin with 10 per cent zinc oxide applied to the skin just before exposure to the sun, provides sufficient protection in many cases After the ointment has been rubbed into the skin powdered talc may be applied. The following cream may be applied so thinly as to be inconspicuous and yet give adequate protection.

℞	Salol	gr v
	Tannic acid	ʒss
	Cold cream	q.s. ad ℥i

M.

Patients with well-developed farmers' skin should have the involved areas inspected at least once a year It is well to destroy the keratoses with electrodesiccation. An ointment, such as the one subjoined may be rubbed into the skin at night to combat the excessive dryness also an almond emulsion may be applied several times daily

℞	Lanolin, anhydrous	ʒii
	Olive oil	ʒi
	Vaselin	ʒii
	Cold cream	q.s. ad ℥i

KERATOSES

The lesions known as the keratoses are among the most common and most frequent of the forerunners of cancer The keratoses that will be discussed here are the senile keratosis, seborrheic keratosis, arsenical keratosis and the industrial keratosis

Senile Keratosis.—The senile keratosis is seen most commonly on the face and the backs of the hands in persons past middle life. They

are perhaps more common in light than in dark skin. They are seldom encountered in negroes American Indians and Arabs The clinical appearance depends on the stage of development The lesions range in size from the head of an ordinary pin to a silver quarter and occasionally larger They consist mainly of a thickened horny layer or scale which is firmly adherent. The scale may occasionally exfoliate, which gives the impression of improvement. It is unusual for an untreated senile keratosis to disappear permanently The lesions may be very slightly elevated or considerably so depending on the amount of hyperkeratosis and inflammatory changes When the lesion consists of more than a thickened horny layer one should suspect the early stage of epithelioma that is if there is any evidence of acanthosis or infiltration—any thickening other than that produced by the scale

The senile keratosis is a dangerous lesion especially when situated on *the mucous surface of the lip Many of them change to epithelioma* sooner or later It is probable that the neoplasm is always of the squamous-cell type when situated on the mucous surface of the lip When the keratosis is situated in the skin, the resulting epithelioma is usually of the squamous-cell type. Eller and Ryan [10] state that it is always of the squamous-cell type

Senile keratoses of the lip so frequently give rise to cancer that we advise the destruction of all such keratoses as soon as detected Whether or not a given senile keratosis of the skin should be destroyed is a matter of judgment. As a general rule it is preferable that they be eradicated, especially when the patient has a reasonably long expect

FIG. 4.—Senile skin showing atrophy "permanent freckles and both senile and seborrheic keratoses.

ancy of life A very old person may have one several or many lesions. In such instances it is often advisable to keep the patient under observation and treat only the lesions that appear to be changing from keratosis to cancer Many senile keratoses never give rise to cancer When cancer does develop on a senile keratosis, the evolution is usually slow so that the physician has plenty of opportunity to detect the transition provided the patient remains under observation

One of the best treatments for senile keratosis is electrodesiccation. The area is first cleansed properly, then procainized. The lesion is next thoroughly dehydrated with the electrodesiccating current. The mummified tissue is removed with curet or scissors, and the base of the wound is again electrodesiccated. When there is the slightest suspicion of epithelioma the treatment is of course that advised for malignant neoplasms Many persons, especially society women with lesions on the face prefer to avoid scars or any permanent defect such as depigmentation However, when treating a senile keratosis it is advisable to concentrate on a permanent cure rather than on avoiding a permanent defect. Radium and roentgen rays are efficacious, when properly applied for selected cases The same statement may be made for solid carbon dioxide the electric cautery and various caustics. Persons who have a tendency to develop senile keratosis on the mucous membrane of the lip and on the skin should avoid excessive exposure to strong actinic light, and it is well to apply ointments and creams frequently

Seborrheic Keratosis.—As a rule seborrheic keratoses are divided into two main varieties—hyperkeratotic and nevoid The *hyperkeratotic* variety will be described first. This type of keratosis is most common on the face scalp and trunk. Seborrheic keratoses may develop as early as the third and fourth decades, but they are far more common in middle aged and elderly persons They are, perhaps, more common on very oily (seborrheic) skins In size, they correspond with the senile keratosis The color is usually dark brown The scale is usually waxy or greasy and as a rule it can be rather easily removed The scale often sheds spontaneously but almost invariably recurs The lesions are well circumscribed and only slightly elevated as a rule Occasionally one encounters a seborrheic keratosis that is verrucous.

The seborrheic keratosis is not very dangerous. Some dermatologists aver that they never give rise to epithelioma. The majority of dermatologists including the writers are of the opinion that an unknown percentage of these lesions do give rise to epithelioma which however, is usually of the basal-cell type

Obviously it is important to distinguish between a seborrheic and a senile keratosis Usually they can be differentiated clinically by the gray dry adherent scale of the senile keratosis as compared with the dark brown waxy removable scale of the seborrheic keratosis. At times it is imp[ossi]ble to make the distinction In such instances it is

preferable either to regard the lesion as of the senile type or to make a microscopic examination.

From the standpoint of danger it is not necessary to remove seborrheic keratoses provided the lesions are occasionally inspected. As a rule, however, it is preferable to destroy them in order to prevent possible development of basal-cell epithelioma and even squamous-cell epithelioma and also for cosmetic reasons. When situated on the exposed parts, especially in women, it is advisable to avoid leaving a scar if possible.

In the early stage of evolution it is possible permanently to remove many lesions simply by the application of trichloracetic acid. When the scale is quite thick it is preferable first to remove the horny layer with a curet and then apply the acid. Often this can be done without a local anesthetic. Radium is frequently efficacious but recurrences are common. When carefully applied the lesion is apt to disappear without leaving a trace. Solid carbon dioxide is used for this purpose by some dermatologists but it is not a popular remedy. The most popular agent and probably the one that is most certain permanently to cure the lesion is electrodesiccation.

NEVOID KERATOSIS.—This variety of keratosis occurs on the face and trunk of people over 30 years of age, most commonly after the age of 50. In size the lesions range from the head of an ordinary pin to a fifty-cent piece and even larger. They are sharply marginated, consid

FIG. 5.—Hyperkeratotic and nevoid seborrheic keratoses.

erably elevated, usually dark brown or brownish-black in color, often shiny and smooth. Usually there is no perceptible thickening of the horny layer—no scale They should be differentiated from nevi which they rather closely resemble. As in the case with the other varieties of keratosis, there may be a single lesion a few or many

It is probable that the percentage of cases of epithelioma arising from the nevoid keratosis is small It is also probable that the majority of such epitheliomas are of the basal-cell type

The nevoid keratosis is not, therefore, considered a very dangerous lesion However, inasmuch as they are unsightly and, particularly because they may give rise to cancer, possibly of the squamous-cell type it is customary to destroy them. Under local anesthesia the lesion is dehydrated with electrodesiccation or coagulated with electrocoagulation. It is then removed with the curet, and the base of the wound is electrodesiccated They may also be excised Finally they may be let alone and inspected once yearly Radium and roentgen rays are not very efficacious.

FIG. 6—Arsenical keratoses with squamous-cell epithelioma.

Arsenical Keratoses.—Arsenic, no matter how administered if taken in large doses or over a long period of time especially in idiosyncratic persons may cause keratoses Most of the arsenical keratoses have been caused by the oral administration of arsenic (Fowler's solution Donovan's solution sodium arsenate etc.) in small, moderate and large doses for long periods of time without suitable rest periods. Arsenic as a rule should be given in courses with intervals of one

or several months between courses Also, the patient should be carefully observed for low toleration

The keratoses show a predilection for palms and soles Occasionally, the affection is more or less generalized It is often accompanied by widespread punctate pigmentation of the trunk The characteristic picture is excessive dryness of palms and soles with almost innumerable punctate deep-seated keratoses Occasionally, very large thick lesions are encountered. Both basal-cell and squamous-cell epitheliomas are prone to develop on arsenical keratoses.

The affection is treated with copious applications of grease The patient is kept under observation and individual keratoses that are active—that is, those that continue to evolve—are destroyed with electrodesiccation. The area should be procainized and the keratosis should be completely eradicated In recent years it has been customary to administer intravenously a freshly prepared solution of sodium thiosulphate but no one has yet conclusively proved that such treatment has any influence on arsenical keratoses or that the formation of additional lesions can in this way be prevented.

Industrial Keratoses (Industrial Keratoderma Occupational Keratoderma) —Keratoses often precede the development of industrial cancer of the skin That cancer of the skin is a problem of some magnitude in industrial medicine can be appreciated by a review of the industries in which this condition develops. Workers come in contact with tar in the following occupations Anthracite laborers aniline dye workers benzine distillers chimney sweeps coal oil workers creosote workers gas-works stokers lamp-black workers pitch handlers sprinklers of soot (gardeners) paraffin workers, road tar sprayers tar distillers and many others

Workers come in contact with arsenic in the following occupations sheep-dip workers workers in Paris green, those who make or handle wall paper smelters of ores furriers tanners tree and shrubbery sprayers taxidermists etc

In addition to keratoses caused by tar products and arsenic, there are those occurring in persons working with roentgen rays and radium in shale-oil workers and so on.

Persons who work in these various industries and who show a tendency to develop keratoses in spite of proper hygiene should change their occupation.

Cancer in these cases which is usually of the squamous-cell type is usually preceded by a long-standing follicular dermatitis or follicular keratoderma. Occasionally keratoses of the senile type occur The dermatitis or keratoderma may disappear with change of occupation cleanliness and soothing topical remedies If not, the patient must remain under observation. Keratoses ulcers that refuse to heal and nodules should be excised or destroyed with electrodesiccation or electrocoagulation

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in the same manner Small areas of leukoplakia may be destroyed with radium the electric cautery or with electrodesiccation the last being the most popular method for the purpose Large areas of

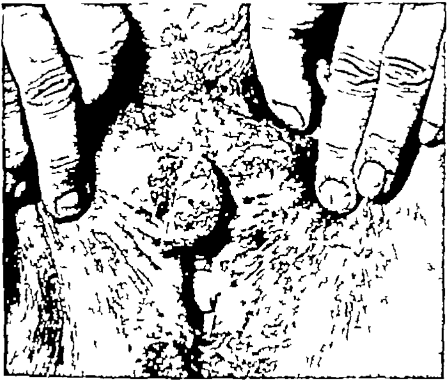

FIG. 8—Kraurosis vulvae with squamous-cell epithelioma.

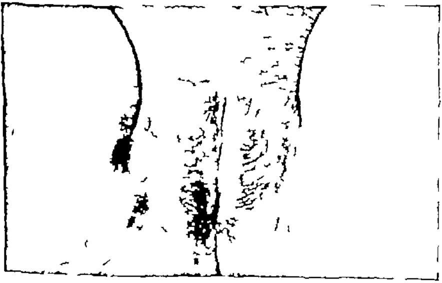

FIG. 9—Same as Fig. 8 After surgical diathermy and roentgen ray treatment.

KRAUROSIS VULVAE

This malady involves the mucous membrane of the female external genitalia. It seldom occurs before the age of 40 or 50 The first symptom may be a recalcitrant pruritus which becomes very annoying The membrane becomes atrophic, sclerotic pale, and leukokeratotic. The leukokeratotic changes are probably identical with leukoplakia of the buccal mucosa. The incidence of squamous-cell epithelioma in this affection has been estimated to be about 10 per cent.

As a rule it is well to treat this disease conservatively and to inspect the involved parts at least every six months Excellent local hygiene is indicated Itching may be relieved with nonirritating topical anti

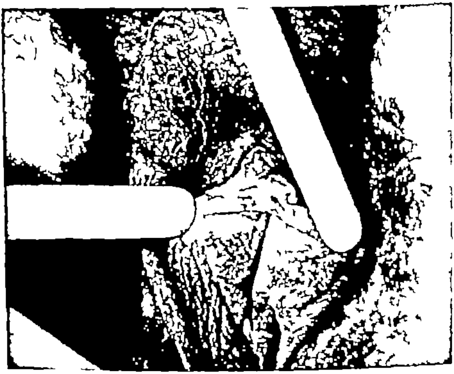

FIG 7—Kraurosis vulvae showing sclerosis and leukoplakia.

pruritics such as lotions and ointments containing small quantities of menthol butesin anesthesin phenol etc Roentgen rays may be used as an antipruritic if necessary but such treatment should be limited to one or two short courses of fractional doses Alcohol injections and resections of the sensory nerves of the perineum are other methods of controlling vulvar pruritus Radium may be of value for small areas of leukoplakia Ulcers and erosions that do not heal quickly should be excised or destroyed with the actual cautery or with high-frequency electricity preferably the latter Vegetations and nodules are treated

uous as a rule. The affected area may develop fissures erosions or ulcers or it may become verrucous or vegetating Such lesions are especially dangerous, but it should be borne in mind that epithelioma may develop suddenly and rapidly in an apparently inactive patch of leukoplakia. When epithelioma develops in leukoplakia it is always of the squamous-cell type As a rule the early evolution of the cancer is slow occasionally it is rapid

The affection must be differentiated from lichen planus lupus erythematosus aphthous ulcers moniliasis and Vincent s angina The mouth lesions of lichen planus are punctate striated annular papular and usually accompanied by skin lesions Lupus erythematosus rarely involves only the mucosa. The lesions are more inflammatory—congestion, edema, and erosions The other diseases may be differentiated by acute symptoms, concomitants and bacteriologic examinations.

Treatment.—It is customary to destroy small patches of leukoplakia with electrodesiccation or with the electric cautery Many such lesions may be permanently cured with a single intense application of the beta or gamma rays of radium If however the lesion is stubborn it is preferable to resort to the previously mentioned treatment rather than give repeated applications of radium Large quiescent areas may be treated with radium but it is preferable to treat them palliatively Dental hygiene must be perfect. Tobacco is prohibited Active areas should be excised or destroyed by the methods enumerated above Treatment that is incapable of completely destroying the lesion should be avoided If the patient has syphilis modern antisyphilitic treatment is indicated The mouths of patients with leukoplakia should be inspected every few months.

MISCELLANEOUS MOUTH CONDITIONS

Chronic gingivitis pyorrhea alveolaris apical abscess sinuses fistulas, erosions ulcers decayed teeth etc favor the development of cancer

The dental profession deserves a great deal of credit not only for superb mechanical ability but because of the recognition that perfect oral hygiene is an exceedingly important health factor The modern dentist urges his patients to have the teeth cleaned by a prophylactic dental nurse at least twice yearly at which time the dentist inspects the entire mouth Undergraduate and postgraduate instruction in diseases of the oral mucosa is given in many dental schools and dental societies. This knowledge, together with periodic dental examinations should materially lessen cancer incidence The dentist has the opportunity to detect many of the conditions that lead to cancer Some of these must be treated by the dentist others should be called to the attention of the family medical adviser

leukoplakia, in the absence of ulcers, erosions fissures, verrucous excrescences and vegetations, may be let alone and kept under observation It is preferable however, to perform a partial or complete vulvectomy followed by plastic repair Such operation is essential when there is widespread leukoplakia, sclerosis and areas of erosion, ulceration and other danger signs.

LEUKOPLAKIA (LEUKOKERATOSIS)

It is the consensus of opinion that leukoplakia of the mouth may occur in both syphilitic and nonsyphilitic persons and in smokers as well as non-smokers Its etiology has not been definitely determined. Presumably it can be caused by syphilis and by local irritation. As a rule, antisyphilitic treatment has little if any effect on leukoplakia. When occurring in syphilitic persons it is often associated with interstitial glossitis and smooth atrophy, a triad that is probably more dangerous than uncomplicated leukoplakia.

It is a fairly common affection in men, only about five per cent of the cases occur in women While leukoplakia is dangerous it is probable that many cases perhaps the majority, never develop cancer

FIG. I.—Syphilitic interstitial glossitis, smooth atrophy leukoplakia and erosions.

FIG. II.—Syphilitic interstitial glossitis, smooth atrophy leukoplakia and squamous-cell epithelioma.

Leukoplakia may occur in one or several very small patches on the tongue lips or mucous surfaces of the cheeks or most of the buccal cavity may be involved Small patches on the gums under the tongue on the roof of the mouth behind the molars etc., may escape careless examination

The patches are white usually marginated, irregular in size and shape slightly thickened and a trifle rough The patient is often conscious of the affection although subjective symptoms are not conspic

all other scars and sclerosed tissue cancer in lupus vulgaris probably because of the dense fibrous tissue and sparse blood vessels and lymphatics is likely to evolve slowly at first and to be of a comparatively low degree of malignancy

The early stage of cancer in these cases is often mistaken for active lupus. Indeed the clinical diagnosis may be difficult. Warty excrescences a vegetating tumor a pearly nodule or a stubborn ulcer having an indurated margin when occurring in a patch of lupus vulgaris or in scar tissue left by the disease should be regarded with suspicion In all such cases a biopsy should be performed The treatment is that recommended for cancer—excision plastic surgery surgical diathermy and in selected cases roentgen rays and radium.

NEVI

Of the many forms of birth marks the most dangerous is probably the almost flat smooth hairless blue-black mole Many of the melanomas have their origin in lesions of this type While malignant

FIG. 3—Blue black mole

change may be spontaneous it is much more likely to follow traumatism, frequent irritation or injudicious treatment.

If such a lesion is quiescent and in a location where it will not be irritated, it may be let alone But when there is the slightest evidence of activity such as increase in size or thickness ulceration, crusting etc. (Hutchinson s malignant lentigo) or if there is possibility of repeated injury the lesion should be radically destroyed As a rule it is preferable to remove malignant lentigo This may be accomplished by a wide deep excision or it may be radically destroyed with surgical diathermy Radium and roentgen rays have produced excellent results in some cases

There is a controversy relative to the advisability of removing an apparently quiescent blue-black mole In the past, attempts at removal have been so often followed by recurrence and metastasis that many physicians prefer to do nothing While it is true that many of these lesions never give rise to melanoma very frequently indeed they do so

LUPUS ERYTHEMATOSUS

Epithelioma of the squamous-cell type occasionally develops in the sclerotic tissue caused by the discoid variety of lupus erythematosus. The neoplastic evolution is at first slow, but as soon as normal tissue becomes involved the growth becomes fairly rapidly invasive. Like most epitheliomas that develop in scar tissue the grade of malignancy is comparatively low A persistent ulcer or erosion, a nodule or a vegetation occurring in an area of lupus erythematosus or in sclerotic tissue resulting from a patch of lupus erythematosus should be excised or destroyed with surgical diathermy Roentgen rays or radium may be used, but the result is less certain

It has been said that epithelioma, when apparently caused by lupus erythematosus is really due to excessive roentgen ray or radium treatment. Undoubtedly this is true in some cases but epithelioma occurring in cases of lupus erythematosus has been reported in the absence of such treatment. Squamous-cell carcinoma occurs as a complication of lupus erythematosus in about 4 per cent of the cases

FIG. 12.—Lupus erythematosus and squamous-cell epithelioma.

Gold and bismuth therapy have replaced, for the most part, all other therapeutic agents for this disease Roentgen rays and radium are very seldom used for this purpose Intravenous injection of gold sodium thiosulphate cures or controls many if not most of the cases. It will be interesting to compare lupus cancer statistics of the past with those compiled during the next twenty five years.

LUPUS VULGARIS

It has been estimated that squamous-cell epithelioma develops in about 2 per cent of cases of lupus vulgaris It is undoubtedly true that some of these cancers are due to the excessive use of roentgen rays or radium On the other hand cancer in lupus vulgaris lesions or scars was reported before the advent of roentgen rays and radium. As in

The blue-black mole should never be treated with caustics nor should it be squeezed It should be let alone or completely removed.

The very common mole—pinhead to split pea-sized elevated smooth more or less pigmented (various shades of brown) with or without hairs—is not considered dangerous unless subjected to repeated irritation Large brown nevi flat or elevated with or without hair in the absence of traumatism are not very dangerous lesions Cerebriform and other soft nevi are dangerous as a rule only when irritated or injudiciously treated The same statement may be repeated

Fig. 5.—Pigmented hairy nevus.

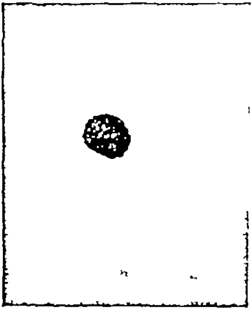

Fig. 16.—Papillomatous, verrucous nevus.

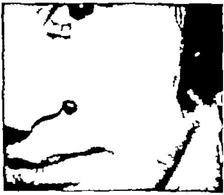

Fig 7.—Mutiple dark brown nevi.

When we are certain of the diagnosis, we prefer to remove this type of lesion by scalpel surgery provided, of course that the location and size are suitable for such treatment. An incision is made through the skin at least one-quarter inch beyond the well-defined margin of the lesion The incision then extends outward and downward to the muscle. When the tissue is removed, the lower portion will be wider than the upper portion The excision is made in this way because occasionally the pigment-bearing cells may follow nerves and blood vessels downward and outward The tissue should be examined immediately by frozen section or with a powerful magnifying lens, and, later serial sections should be carefully examined under the microscope. In this way the diagnosis is established also it is ascertained whether or not the lesion was completely removed If not completely removed a wider excision is made. The excision may be made either with a scalpel or with the cutting current. We prefer the former because surgical dia

FIG. 14.—Common moles.

thermy in any form may interfere with a satisfactory microscopic examination.

As a rule the blue-black mole is a small lesion (pinhead-sized or split-pea sized) Occasionally they are much larger—too large for excision Occasionally too the situation precludes ordinary excision. In such instances the lesion may be let alone and kept under observation or it may be removed by plastic surgery depending on the judgment of the physician and the attitude of the patient and family

The blue-black or gun metal or slate-colored mole may be confused with dark-brown much less dangerous nevi. It may be closely simulated at times by a tiny sebaceous cyst that happens to contain pigment or in which the refractive index is such as to produce a bluish-black appearance also very small hemorrhagic cysts may simulate malignant lentigo The diagnosis therefore, is not always easy

Moles may be present at birth or they may appear months or years sometimes many years after birth

be treated as a means of cancer supervention depends upon type location condition and the judgment of the physician In selecting treatment for a given lesion it is well to choose a method that is universally recognized as safe and proper Many deaths have been caused by the incomplete destruction or the irritation of dangerous types of nevi with acids solid carbon dioxide electrodesiccation electrolysis and other inadequate methods

PAPILLOMA OF THE TONGUE

These lesions may be single or multiple They are usually situated on the dorsal surface in the area of papillae They are considered slightly dangerous because they are so likely to be repeatedly irritated or traumatized It is advisable to destroy them with electrodesiccation They may, of course, be excised either with scalpel or with the cutting current.

RADIODERMATITIS

This term includes all cutaneous injuries caused by roentgen rays or radium A description of radiodermatitis is given in Chapter 4 Volume III Severe acute radiodermatitis may result in an ulcer which never heals Such an ulcer is dangerous because cancer is likely eventually to occur Even when the ulcer heals, it leaves a scar that is far more dangerous than are ordinary scars It is advisable to excise ulcers of this kind by a plastic operation if necessary By so doing the patient is spared both time and severe pain and also danger of subsequent cancer is removed

A dangerous sequel of excessive roentgen ray or radium treatment is the so-called roentgen ray or radium skin This consists of atrophy or sclerosis telangiectasia and keratoses These sequelae may result from an acute reaction with or without ulceration or they may be the result of too many fractional treatments with or without a mild first degree reaction

Permanent roentgen ray and radium injuries should be occasionally inspected. In many instances the skin remains slightly atrophic and perhaps telangiectatic throughout the remainder of the patient s life, without the development of lesions that are dangerous On the other hand keratoses may develop These keratoses may or may not lead to cancer They frequently do so They should at least be kept under observation. As a rule it is advisable to destroy them. This can be done with electrodesiccation In our opinion radium and roentgen rays are contraindicated for this purpose

Skin that has been badly injured with roentgen rays or radium is likely to ulcerate when irritated or traumatized It may ulcerate spontaneously The ulcer may or may not heal If it does not heal it is very likely to end in cancer

for verrucous nevi Cancer rarely, if ever, develops on vascular nevi and lymphangiomas

Nevi of various types are exceedingly common Almost every person has at least one mole of the common variety It is by no means necessary or advisable to destroy all moles, but their inspection should be a part of periodic health examinations Whether or not a nevus should

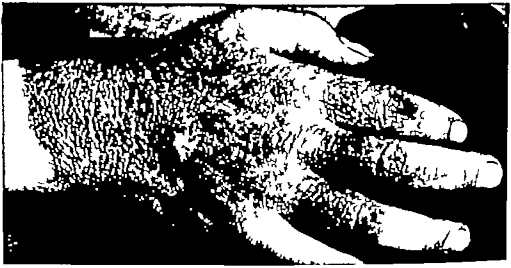

FIG. 18.—Pigmented, keratotic nevus with malignant neoplasm.

FIG. 19.—Cerebriform nevus.

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FIG. 10.—Chronic radiodermatitis with squamous-cell epithelioma.

When skin of this type shows a tendency to ulcerate or to form frequent and numerous keratoses it is advisable to remove it by excision or by a plastic operation If this is impossible the keratoses should be destroyed and the patient kept under observation.

SEBACEOUS CYSTS (STEATOMA ATHEROMA, WEN)

Ricker and Schwalb [11] report 43 cases of sebaceous cyst in which cancer developed in the cyst wall Caylor reported 12 similar cases [12] When cancer occurs it is usually a squamous-cell epithelioma although basal-cell epitheliomas have been reported Malignant change occurs more often when the cyst first undergoes ulceration. Sebaceous cysts are exceedingly common and they are easily removed by excision.

Fig 21—Sebaceous cyst

Fig 22—Same as Fig. 2 After excision.

SYPHILIS

Cancer is a frequent complication of interstitial glossitis and smooth atrophy of the tongue of late syphilis The same may be said of syphilitic leukoplakia. The management of leukoplakia has been already discussed Little can be done for the other two conditions The patient should be kept under observation and of course he should receive antisyphilitic therapy Early cancer of the tongue in these cases is frequently mistaken for gumma or other manifestation of syphilis a mistake that can be avoided by microscopic examination Many dermatologists believe that the administration of arsenic increases the danger of cancer in cases of syphilitic glossitis smooth atrophy and leukoplakia We doubt the contention

Cancer may occur in scars left after the healing of destructive lesions of syphilis. Also cancer has been reported in cases of gumma but most of these reports were of tongue cases and it is probable that they were cases of squamous-cell epithelioma occurring in interstitial glossitis rather than in a gumma.

ULCERS AND FISTULAS

A few cases of squamous-cell epithelioma developing in long-standing varicose ulcers of the leg have been reported The incidence of malignancy is very small when one considers the frequency with which the so-called varicose ulcer occurs In the literature one finds frequent reports of metastatic cancer occurring in ulcers of various types decubitus ulcer pellagrous ulcers ulcerations in acrodermatitis chronica atrophicans and scleroderma, third degree burns and, of course ulcers caused by roentgen rays and radium.

Cancer following long-standing fistulas and sinuses caused by disease or injuries has been frequently reported. We recently saw a case of osteomyelitis the result of an accident, which had failed to respond to the usual treatment. A sinus formed, followed by squamous-cell epithelioma of relatively low-grade malignancy, necessitating amputation of the leg.

FIG. 23.—Von Recklinghausen's disease.

VON RECKLINGHAUSEN'S DISEASE (MULTIPLE NEUROFIBROMATOSIS)

Hosoi[11] reports 65 cases of this affection in which sarcoma developed He states that sarcoma develops in 13 per cent of the cases of multiple neurofibromatosis This figure seems high to us. We have seen many cases of multiple neurofibromatosis but we have not seen a single case of associated sarcoma.

It may be that of all cases of von Recklinghausen's disease in which tumors are excised 13 per cent become sarcomatous after surgical interference. Hosoi reports one case in which sarcoma developed one year after the excision of a tumor It has been observed by others that removal of a tumor by surgical excision may result in sarcoma These sarcomas are not very malignant and seldom undergo metastasis yet the prognosis is poor Recurrence after repeated operations is the rule If death does not result from metastasis it follows operative and postoperative complications

The course of von Recklinghausen's disease is not modified by treatment of any kind It would seem that surgical intervention were contraindicated.

XERODERMA PIGMENTOSUM

This rather rare affection is thought to be due to congenital lack of resistance to sunlight. It begins early in life there is a predilection for the exposed parts and it is incurable The affection simulates chronic radiodermatitis sailors or farmers skin and senile skin Pigmentation and atrophy are first noted This is followed by keratoses and epithelioma, usually of the basal-cell type

Very little can be done for these unfortunate children. Only those with a mild example of the affection reach adult life These patients should be thoroughly protected from even indirect sunlight. Preferably they should be exposed only to artificial light which contains few if any actinic rays. When in the open they should wear gloves sleeves dark-colored veils etc. Keratoses epitheliomas and ulcerations should be destroyed as soon as detected. This can be done as a rule, with electrodesiccation

MISCELLANEOUS CONDITIONS

The skin of elderly persons may show atrophy permanent freckles (lentigo) and keratoses The condition is usually more pronounced on the face and hands although it may occur on the trunk and in fact, on almost any part of the body It may occur in those who have never been exposed very much to actinic rays It resembles sailors skin and is known simply as senile skin Occasionally it begins between the ages of 35 and 50 without apparent reason. This has been called presenile skin. The keratoses occurring in such skin have the same potentialities as senile keratoses and are treated in the same manner

FIG. 14.—Xeroderma pigmentosum

Permanent freckles with predilection for face shoulders and backs of hands may be a manifestation of senile skin or of farmers skin They occur mostly after the age of 60 although they are fairly common at 40 and 50 Occasionally one of these pigmented macules may change to a keratosis and the latter may give rise to cancer However

Fig. 25—Neurofibroma

Fig. 26.—Same as Fig 25 After excision.

Fig. 27—Neurofibroma.

Fig. 28—Same as Fig. 27 After excision.

this happens so seldom that it is not necessary to treat a permanent freckle unless a keratosis develops

Sebaceous adenomas are pinhead sized umbilicated papules seen most frequently on the forehead of middle-aged and old persons The color is about that of normal skin We think that we have seen epithelioma develop in these lesions The condition is to be differentiated from adenoma sebaceum.

Fig. 29.—Fibroma.

Fig. 30.—Same as Fig. 29. After excision—four days after operation.

Fig. 31.—Fibroxanthoma (histiocytoma)

Fig. 32.—Same as Fig. 31. After excision.

Lesions falling in the category of multiple benign cystic epithelioma —tricho-epithelioma syringocystoma etc —occasionally change to a malignant neoplasm usually basal-cell epithelioma. The same is true for certain endotheliomas In fact there are a large number of benign lesions such as fibroma neurofibroma fibroxanthoma etc. that may under certain conditions give rise to cancer However none of these lesions is considered dangerous unless repeatedly irritated over a long period of time. Paraffinoma has been known to change to cancer Cancer has been reported in cases of Darier s disease (keratosis follicularis) Acanthosis nigricans in adults usually indicates cancer of the viscera.

Fig 33 —Syringocystoma.

Cutaneous Malignant Neoplasms

General Therapeutic Considerations.—In the past, dermatologists and others treated cutaneous cancer with the method with which they were most familiar regardless of type, size, depth and location of the lesion Thus the surgeon always employed the scalpel, the roentgenologist depended solely on roentgen rays the radium specialist used only radium, the diathermy enthusiast insisted on the use of surgical diathermy and so on The same statement is true today but to a lesser degree Statistics show that excellent results may be obtained in properly selected cases with any of these methods when expertly applied The results are not so good in unselected material. There is no best method for the treatment of unselected cases of cutaneous malignant neoplasms Any one method or a combination of methods may be the best procedure for an individual case The physician who has had extensive experience with all the recognized methods of treating malignant neoplasms of the skin and orificial mucous membranes and who is thoroughly acquainted with the clinical and histologic characteristics of such neoplasms and the conditions that may cause them, is in a position to employ discriminating judgment and to obtain the best results. Undoubtedly statistics will improve when every physician who attempts the management of cutaneous cancer possesses this comprehensive ability Here, too, there is need for more and better postgraduate instruction

The recognized methods of treating cutaneous malignant neoplasms are scalpel surgery surgical diathermy, roentgen rays and radium.

Roentgen Rays.—Roentgen rays are satisfactory for many basal cell epitheliomas Small superficial growths may be treated with unfiltered radiation. Moderate or heavy filtration is preferable for thick or deep-seated lesions It seems that approximately the same results are obtained by large doses administered at intervals of two or more months or by smaller doses so spaced that an intense effect is obtained in a week or two (fractionation) It should be emphasized that when a lesion fails to respond favorably to treatment that should be adequate the treatment should be discontinued. When containing squamous cells when involving cartilage and other subcutaneous structures, and when composed of hard nodules basal-cell epitheliomas are likely to resist roentgen rays Many basal-cell epitheliomas will disappear with hardly a trace as a result of roentgen ray therapy but the cosmetic result is occasionally disappointing because of atrophy and telangiectasia subsequent to radiation and scarring caused by the disease.

Roentgen rays produced by very high voltage, and heavily filtered, are very useful for selected cases of squamous-cell epithelioma and, also for inoperable cases.

Radium.—In general what has been said relative to roentgen rays may be repeated for radium Radium is the more preferable of the two agents for unselected cases of cutaneous squamous-cell epithelioma. It can be used in locations that are inaccessible to roentgen rays There is better opportunity for cross-fire radon implants may be used there is greater penetration and so on For selected cases assuming proper facilities and expertness the results are probably approximately the same with either agent It may be interjected that the facilities and skill required for the modern roentgen ray and radium treatment of squamous-cell epithelioma, even of the skin and orificial mucous membranes are so exacting that they are found in comparatively few medical institutions and private offices In the near future it may be possible to employ in practical work, roentgen rays produced by a million or more volts and filtered with heavy metal of considerable thickness Such radiation will compare favorably in penetrability with heavily filtered gamma rays

Surgical Diathermy —The production within the tissue by means of a high-frequency current of an amount of heat sufficient for destructive purposes is known as surgical diathermy Three forms of surgical diathermy are universally employed They have been designated electrocoagulation cutting current and electrodesiccation The first two depend on current obtained from various parts of the primary winding of the high frequency transformer Either of these currents may be bipolar or monopolar damped or undamped. The current for electrodesiccation is monopolar and it is obtained from the secondary winding of the high frequency transformer

With electrodesiccation it is possible by surface sparking to dehydrate or mummify a pinhead-sized superficial area or a fairly extensive superficial lesion By multiple insertions of the active needle electrode one may destroy rather large thick lesions The method is employed mostly for the destruction of small, superficial benign growths, potentially dangerous lesions such as leukoplakia keratoses etc. and small superficial epitheliomas of the basal-cell type It is being abused by many physicians who employ it mistakingly for electrocoagulation and who use it without any form of anesthesia.

The current for electrodesiccation has an exceedingly high voltage and a comparatively low milliamperage. That for electrocoagulation has a lower voltage but a higher milliamperage The cutting current has still lower voltage and higher milliamperage

The electrocoagulating current, when used as a surface spark dehydrates to some extent but the principal effect is that of rather widespread coagulation of tissue especially when the active needle electrode is inserted into the tissue as is usually done The gross change may be no more than a blanching or whitening of the tissue which later sloughs Electrocoagulation seals the blood vessels and lymphatic vessels It is used mostly for the destruction of malignant neoplasms.

It is customary first to establish a line of deep coagulation beyond the periphery of the lesion the entire lesion is then coagulated and removed with the cutting current scalpel or curet, after which the wound may be electrodesiccated or superficially electrocoagulated. Coagulation can be performed with the bipolar current, using either a single or bipolar active needle electrode or with monopolar current from the same source

The cutting current cuts like a knife and causes enough coagulation to seal the small blood vessels and lymphatic channels Theoretically at least there is less chance of metastasis during the application of surgical diathermy than with the scalpel or curet. Excision with the cutting current is comparatively bloodless It is possible to obtain primary union especially if the edges of the wound are freshened with the scalpel or scissors

Surgical diathermy can be employed satisfactorily when scalpel surgery would be difficult or impossible When using high frequency currents for destructive purposes, one is likely to think in terms of physical therapy rather than in terms of surgery which may lead to careless technic from a surgical standpoint. Surgical diathermy is surgery, and to it should be applied the principles of general surgery

Good results may be obtained by the use of the actual cautery

Sherwell Method.—There is another therapeutic method occasionally used by dermatologists for selected cases of cutaneous cancer which may be placed among the conventional methods. We refer to the Sherwell method. It consists of the removal of as much of the neoplastic tissue as is possible with curet, scalpel, scissors, and high-frequency current, after which acid nitrate of mercury is applied for at least five minutes The wound is then covered with a thick layer of bicarbonate of soda, over which is placed a dry dressing. Instead of acid nitrate of mercury Morrow and Taussig [14] employ chemically pure red crystals of chromic acid, while Angle [15] and others use a saturated aqueous solution of zinc chloride.

Contraindicated Treatment.—Some physicians advocate the use of physical therapy agents for the treatment of cutaneous cancer that have been given a fair trial by dermatologists who find that they are unsuitable for the purpose Among these agents are solid carbon dioxide electrolysis and ultraviolet radiation.

Biopsies.—When possible it is advisable to make a microscopic examination before instituting treatment. This is the only way in which a definite diagnosis can be made Also it is the only way in which the grade of malignancy can be accurately determined. When the lesion is small and suitably situated, the biopsy might well consist of complete excision with the scalpel Examination of serial sections provides invaluable information relative to invasiveness, metastasis and complete or incomplete removal in addition to determining

the grade of malignancy based on cytology tissue reaction and other features

Many physicians aver that a biopsy made with scalpel or biopsy punch is dangerous that such procedure favors dissemination of the malignant cells They prefer to remove the piece of tissue with the cutting current. It is now the consensus of opinion of those who have had extensive experience that a biopsy made with scalpel or biopsy punch is not dangerous when properly performed The instruments must be sharp and the lesion must not be squeezed massaged or unduly manipulated The cutting current, unless the excision is very wide is likely to interfere seriously with the microscopic study because of coagulation of cells

Classification of Cutaneous Malignant Neoplasms

There is as yet no universally accepted classification for malignant neoplasms of the skin and orificial mucous membranes In this chapter the following conditions will be discussed

1 Basal-cell epithelioma
2 Basal-squamous-cell epithelioma
3 Squamous-cell epithelioma
4. Transitional-cell epidermoid carcinoma
5 Paget s disease
6 Bowen s disease
7 Melanomas
8 Sarcomas

BASAL-CELL EPITHELIOMA

The term *basal-cell epithelioma* includes names such as Jacob s ulcer cancroid rodent ulcer and benign skin carcinoma, all of which are now obsolete.

Krompecher [14] in 1902 was the first investigator to separate basal cell epithelioma from other epithelial cancers His work has done a great deal to clarify our knowledge of the malignant cutaneous new growths

The basal-cell epithelioma is relatively benign and causes death only by hemorrhage involvement of important parts such as the articulations and orbit or when complicated by septic infection The affection rarely involves the mucous membranes primarily although secondary involvement of these structures is common In other words basal cell epithelioma practically always begins in the skin Metastasis is rare in basal-cell epithelioma of pure type The prognosis both for life and for permanent cure is excellent but must be guarded when dealing with deep lesions It is not necessary to treat every basal cell epithelioma. They should be treated when occurring in patients who are under 60 years of age Small superficial lesions in old and very old persons especially when multiple may be let alone and kept

under observation Evolution is likely to be so slow that the lesion will not become serious during the patient's remaining years. Ulcerated lesions, deep lesions, and lesions that have involved or threaten to involve important structures should, of course, be destroyed, regard less of age Lesions that are in skin that is thin—nose, forehead, eyelids ears etc.—should be watched carefully or destroyed, otherwise underlying important structures may become involved.

The neoplasm originates from the basal-cell layer of the epidermis —most likely from cells that were predestined to form cutaneous appendages It also arises from the basal-cell layer of the epithelium of the cutaneous appendages—sebaceous glands and ducts, and sweat glands and ducts, especially from the sebaceous glands.

FIG. 34.—Flat type of basal-cell epithelioma

Under the microscope the lesion consists of basal cells that fail to develop into squamous or prickle cells therefore, there is no kera tinization no whorls. As a rule there is considerable tissue reaction around the neoplasm.

Clinically the affection varies considerably in appearance due both to clinical type and stage of evolution Usually the evolution is ex ceedingly slow—very slow extension over a period of many months usually many years The affection is most common during or after middle life It is quite common in the third and fourth decades and occurs occasionally during late adolescence The sites of predilection are the face and trunk, although it may occur on almost any part of the body surface Males are affected more frequently than are females.

Hazen[5] classifies basal-cell epithelioma into seven clinical types

1. Flat type
2. Nodular
3. Ulcer with rolled edge
4. Lesion resembling a depressed scar
5. Morphea like epithelioma
6. Fungating tumors
7. Deep type

FIG. 35.—Multiple basal-cell epithelioma of the flat type—multiple epitheliomatosis cutis.

Flat Type.—The flat type consists usually of a brown-colored macule with a delicate rolled edge The edge is slightly elevated narrow and somewhat translucent. In color and appearance the edge

suggests mother-of-pearl They range in size from the head of a pin to split pea, silver quarter fifty-cent piece, silver dollar and larger The bulk of the lesion may be flat (macular) slightly elevated, smooth scaly or crusted It may be studded with pearly nodules and it may ulcerate As a rule the lesion is dry but it may be exudative. The lesion spreads very slowly by peripheral extension The center may cicatrize The lesions very often are multiple, frequently there are many lesions

This type of basal-cell epithelioma is also known as multiple epitheliomatosis cutis and serpiginous cicatrizing epithelioma. At times it resembles the so-called Bowen s precancerous dermatosis extramammary Paget s disease, keratosis seborrheica, psoriasis syphilis, tuberculosis etc. As a rule the clinical diagnosis is easily made. Occasionally a biopsy is necessary If so it is essential that tissue from the margin be examined rather than tissue from the center of the lesion The flat type is very superficial and usually remains so for many years. Eventually it may become nodular or ulcerative and may invade the subcutaneous tissues.

FIG. 36—Basal-cell epithelioma—a pinhead sized nodule t right inner canthus.

FIG. 37—Basal-cell epithelioma—a single nodule with beginning ulceration.

Nodular Type.—Nodular lesions vary in size from pinhead to split pea dime silver quarter and much larger The lesion may consist of a single small nodule a single larger nodule or a closely crowded group of small nodules. The nodules are hard, shiny semitranslucent, elevated and usually pearl white or waxy in color They are called mother of-pearl or xy nodules There is usually some telangiectasia. The lesion ma nain nodular for years or it may undergo ulceration The nod type is at times confused with nodular syphilis lupus vulgaris and other affections The clinical diagnosis is easily made as a

FIG. 38.—Basal-cell epithelioma. Lesion is composed of numerous closely crowded nodules.

FIG. 39.—Basal-cell epithelioma composed of coalesced nodules—beginning ulceration

FIG. 40.—Basal-cell epithelioma composed of a rim of coalesced nodules and a cicatrized center There is some ulceration.

rule. Lesions having an unusual macroscopic appearance give a typical microscopic picture.

Depressed Scar Type.—This is an uncommon type. It consists of a slightly depressed scar or a slightly depressed area of atrophy or sclerosis It may represent what was formerly known as the serpiginous

cicatrizing type There may or may not be ulceration, nodules and a delicate rolled edge Often the clinical diagnosis is difficult. Even the microscopic diagnosis may be difficult unless the area for biopsy is selected with care.

Morphea Like Type.—In this variety the lesions are flat, somewhat round in contour and sharply marginated. The area may be atrophic and slightly depressed, or slightly thickened and elevated The color is yellowish or pinkish yellow and there is usually some telangiectasia. Sooner or later ulceration occurs It is an uncommon type of basal-cell epithelioma.

Fungating Type —In this variety the lesion, which may be of almost any size usually is an ulcer covered with a vegetating or fungoid mass, and associated with a foul-smelling exudate. Waxy

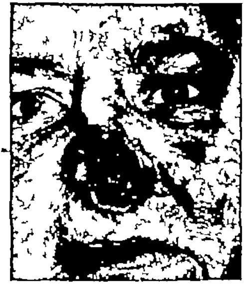

FIG. 41 —Deep type of basal-cell epithelioma.

nodules may appear at the periphery or in various parts of the lesion. Occasionally this type may be papillomatous, giving rise to a cauli flower like tumor or it may be verrucous It may be mistaken for squamous-cell epithelioma, tuberculosis, syphilis blastomycosis, bromoderma, iododerma and other affections

Deep Type.—This form may originate from any of the other types or it may develop independently In the latter case, when first detected it consists of a small nodule deep in the skin or in the subcutaneous tissue The surface is usually red, perhaps atrophic and telangiectatic. The nodule increases in size spreading laterally and downward, in volving the deeper tissues Eventually there is ulceration surrounded

FIG. 42.—Basal-cell epithelioma of skin over shoulder

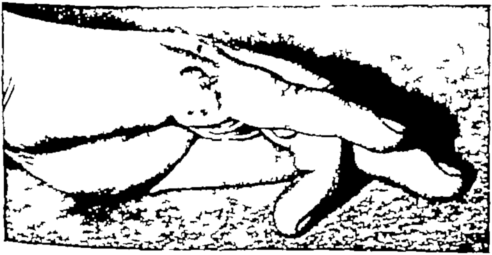

FIG. 43.—Basal-cell epithelioma of finger.

by induration and extensive destruction of tissue. When developing from other types, a deep indurated ulcer is produced which gradually destroys important tissue It is the deep ulcerating type that used to be called rodent ulcer It directly and indirectly destroys subcutaneous tissue, cartilage periosteum the eye and other important structures. When developing independently as a deep nodule it is often impossible to establish a diagnosis without the aid of the microscope

Treatment.—Selection of method for the treatment of basal-cell epithelioma is based on a number of factors such as circumference, thickness and depth of lesion type (superficial deep nodular, ulcerating morphea like, etc.) previous treatment, primary or recurrent growth, location and tissue involved, and age and sex of the patient, and, also, the desires of the patient.

SCALPEL SURGERY —A lesion that does not involve cartilage or periosteum that is suitably situated and that is not too large, may be

FIG. 44 —Basal-cell epithelioma of chin. FIG. 45 —Same as Fig. 44. After scalpel excision.

excised with the scalpel and primary union obtained If the skin heals normally and the surgical technic is proper the ultimate scar is less conspicuous than that following electrocoagulation or electrodesiccation unless the lesion is exceedingly superficial in which case methods other than surgical excision are indicated Excision with the scalpel has, of course limitations but it has the advantage of permitting serial sections of the entire lesion In this way one confirms or refutes the diagnosis n l ascertains whether or not the entire neoplasm has been removed I here is doubt about complete removal a larger excision may be ı de or roentgen rays or radium may be applied. Scalpel

surgery is especially efficacious for the deep type consisting of a small nodule in the skin or subcutaneous tissue

There are many cases in which an extensive neoplasm has involved important organs such as the nose ear eye etc. The majority of such lesions have been previously treated with roentgen rays or radium or surgical diathermy or with all three methods In such instances the best results are usually obtained by removing or destroying all neoplastic tissue by means of conventional surgery or with surgical diathermy after which the deformity is corrected as much as possible with plastic surgery

CAUSTICS —Superficial lesions such as the flat type may be cured by first thoroughly curetting under local anesthesia, then applying

FIG. 46.—Deep type of basal-cell epithelioma of nose.

FIG. 47—Same as Fig. 46. After surgical diathermy

zinc chloride acid nitrate of mercury or when very superficial even trichloracetic acid The Sherwell method is used as a rule, for deep lesions that have involved important structures and in which other methods have failed. The results are excellent when the cases are properly selected

SURGICAL DIATHERMY —This is a popular method among dermatologists Very superficial lesions are dehydrated by electrodesiccation removed with the curet and the wound is again electrodesiccated It is important to extend the destruction of tissue for at least a quarter of

by induration and extensive destruction of tissue When developing from other types a deep indurated ulcer is produced which gradually destroys important tissue It is the deep ulcerating type that used to be called rodent ulcer It directly and indirectly destroys subcutaneous tissue, cartilage periosteum, the eye and other important structures. When developing independently as a deep nodule it is often impossible to establish a diagnosis without the aid of the microscope.

Treatment.—Selection of method for the treatment of basal-cell epithelioma is based on a number of factors such as circumference, thickness and depth of lesion, type (superficial deep nodular ulcerating morphea like, etc.), previous treatment, primary or recurrent growth location and tissue involved and age and sex of the patient, and, also, the desires of the patient.

Scalpel Surgery —A lesion that does not involve cartilage or periosteum, that is suitably situated and that is not too large, may be

Fig. 44.—Basal-cell epithelioma of chin.

Fig. 45—Same as Fig 44. After scalpel excision.

excised with the scalpel and primary union obtained. If the skin heals normally and the surgical technic is proper the ultimate scar is less conspicuous than that following electrocoagulation or electrodesiccation unless the lesion is exceedingly superficial in which case methods other than surgical excision are indicated Excision with the scalpel has, of course limitations but it has the advantage of permitting serial sections of the entire lesion In this way one confirms or refutes the diagnosis and ascertains whether or not the entire neoplasm has been removed If there is doubt about complete removal a larger excision may be made or roentgen rays or radium may be applied. Scalpel

Roentgen rays and radium are very likely to fail when cartilage and periosteum are involved

The majority of operators favor the administration of large doses at intervals of one or two months—from one to six or eight times the erythema dose depending on size of lesion, age of patient location of lesion thickness of filter etc. Unfiltered radiation is used for superficial lesions while moderately heavy and heavy filtration are employed for thick deep-seated lesions

Some operators favor dividing the total dose for one month administering a fraction of the total dose every few days. This has been referred to as the modified Coutard [14a] technic. It is claimed that by so

Fig. 48.—Ulcerated nodular basal cell epithelioma of left inner canthus.

Fig. 49.—Same as Fig. 48 After two intensive doses of roentgen rays.

doing a larger total dose can be given without undue reaction which is probably true and that there is a better chance of catching cells in the act of dividing at which time they are more "radiosensitive. However there is no convincing evidence that this method gives results that are superior to large doses given once every month or two When using a copper filter with very high voltage roentgen rays it may be necessary for technical reasons to give a fraction of the total dose every day or two until the treatment is completed

When a basal-cell epithelioma fails to disappear as a result of two or three large doses of roentgen rays or when it recurs more than once following roentgen ray treatment it is advisable to resort to some other therapeutic method. Normal skin, except that in the immediate vicinity of the lesion, should be adequately protected. Roentgen rays should never be applied to the eyelids without proper protection for the eye ball The eye may be desensitized with a few drops of one or two per cent holocaine solution. Then a brass aluminum or lead glass eye shield is sterilized dipped in sterile olive oil and slipped under the eyelids

Overdosage should be avoided A third-degree roentgen ray reaction

an inch beyond the macroscopic edge of the lesion It is equally im portant to carry the destruction downward into normal tissue A recur rence at the edge of a scar is soon detected A recurrence or continua tion under a scar is likely to do considerable damage before it is recognized Many dermatologists also administer a single dose of unfiltered roentgen rays consisting of from one to three or four skin units—from about 300 to 1200 r, or the equivalent dose of gamma rays of radium.

Lesions that are large, thick and deep are usually thoroughly electro-coagulated The coagulated tissue is removed and the wound is again electrocoagulated This may be accomplished under general or local anesthesia Many physicians prefer to finish the treatment with a hyper intensive dose of filtered roentgen rays—from two to eight skin units (140 Kv 3 mm Al 1100 to 4400 r), depending on size of lesion and age of patient, or filtered gamma rays of radium in equivalent dosage.

A lesion may, of course, be excised with the cutting current fol lowed either by primary union or healing by granulation tissue.

Scars following the destruction or removal of a basal-cell epithelioma with surgical diathermy are likely to be disfiguring especially when the lesion occupies the entire thickness of the derma or has invaded tissue under the skin Very often they are hyperplastic or keloidal. Very superficial lesions may be destroyed with very little scarring

There is no way of knowing when coagulation is used whether or not all the neoplastic cells have been destroyed. On a number of occasions we have excised a scar left by such treatment and have found neoplastic cells in the scar tissue. It is possible that some malignant cells escape destruction in many cases that are permanently cured but because they are entirely surrounded by dense scar tissue, they either remain dor mant or perhaps eventually die In any event it is possible to obtain at least 85 per cent permanent cures in unselected cases of basal-cell epi thelioma with this method. Many superficial lesions, especially the early ones, may be destroyed by the actual cautery

Roentgen Rays —It is possible to cure at least 85 per cent of unselected basal-cell epitheliomas with roentgen rays The percentage of cures in selected cases is of course higher Hazen and Whitmore [17] reported a series of 200 unselected cases with 86 per cent permanent cures They obtained 93 per cent cures in selected cases MacKee [18] in a series of 400 cases obtained 87 per cent cures in unselected cases and 91 per cent in selected cases. Some authors report a much higher percentage of cures, 100 per cent, in fact while others obtained only 60 or 70 per cent. It is doubtful if it is possible to obtain 100 per cent cures in a large series of unselected cases of basal-cell epithelioma with either roentgen rays or radium. It may be possible to approach this figure with thoroughly modern roentgen ray or radium treatment when the cases are selected and when in each case the diagnosis is made microscopically

BASAL SQUAMOUS-CELL EPITHELIOMA

It has long been known that 12 or 15 per cent of basal-cell epi theliomas contain squamous or prickle cells Curiously it is just about this percentage of cases that have proved unusually stubborn. Hamilton Montgomery[19] found this type of epithelioma in 12 6 per cent of a series of 119 cases of skin carcinoma most of which clinically were of the basal-cell type It is difficult if not impossible clinically to differentiate between a pure basal-cell epithelioma and one of the basal-squamous-cell type especially in the early stages of evolution Histologically, one portion of a section may show only basal cells while another portion may show the characteristics of a squamous-cell growth. Quoting Montgomery They represent a metamorphosis of basal-cell epithelioma to squamous-cell epithelioma and are not degenerate forms of the latter It is necessary to study carefully the entire section sometimes several or many sections otherwise the true nature of the lesion may be overlooked This type of epithelioma begins looks and it may behave like a pure basal-cell epithelioma but often it behaves like a squamous-cell growth That is it may prove recalcitrant and it may cause death In the past there have been a few reports of metastasis occurring in cases of basal-cell epithelioma. It is not improbable that these lesions were of the basal-squamous-cell type

The treatment should be the same as that recommended for squamous-cell epithelioma While as a rule the degree of malignancy is not high yet the prognosis should be guarded

Fig. 50.—Basal-squamous-cell epithelioma.

Fig. 5 —Same as Fig. 50 After removal with cutting current followed by roentgen ray treatment.

SQUAMOUS-CELL EPITHELIOMA

The term *squamous-cell epithelioma* (prickle-cell epithelioma) signifies a malignant growth originating from cells of the epidermis above

is likely to be more troublesome and more serious than is the usual basal-cell epithelioma. Very often a basal-cell epithelioma, when treated with roentgen rays will disappear with only a slight cutaneous defect Not infrequently, however there is a scar atrophy or telangiectasia In other words while the chance for a good cosmetic result is excellent the result in this respect may not be satisfactory Of course, the cosmetic result depends on a number of factors—size of dose, location, age, sex, idiosyncrasy, character of the lesion, etc.

RADIUM —In general, what has been stated about roentgen rays in the preceding section pertains, also, to radium Assuming technical skill proper equipment and judgment in selection of cases future statistics will be probably approximately the same for both agents.

In certain locations better results can be often obtained with radium than with roentgen rays—lesions on the edge of the eyelid, lesions including the nasal or buccal mucous membranes, a lesion in the external auditory canal, etc A tubular applicator may be placed in the external auditory canal. A cast or mold of the mouth can be made in which screened radium or radon is embedded in proper position. The mold is held in the mouth during treatment.

Very superficial lesions may be treated with a half-strength radium element applicator screened with 0 1 mm. Al The applicator is held in contact with the lesion for one or two hours Such treatment gives an intense beta ray effect. Deeper lesions should be treated with gamma rays The same applicator is screened with 2 mm of brass and 1 mm. Al This is held in contact with the lesion for from eight to twenty four hours If so desired the time factor may be divided so that an application of from two to four hours is given daily

Lesions that are very deep thick or indurated are usually treated with radon Radon tubes may be screened with 0 5 mm Ag 1 mm. brass and 1 mm. Al Such a tube containing 100 mc. radon is placed at a distance of 2 cm from the lesion and held in place with adhesive for a period of from 2 to 6 hours Such treatment may be repeated in two weeks or a month. In selected cases implants or seeds each containing 1 to 2 mc. of radon are embedded 1 cm. apart throughout the tumor mass. These seeds are not removable Removable platinum radium needles may be used. Needles each containing 1 or 2 mg radium are placed 1 cm. apart in the mass. These are sutured in place for from 96 to 144 hours

GRENZ RAYS —The very long roentgen ray wavelengths known as grenz rays have been used to some extent for the treatment of basal-cell epithelioma. The number of cases treated is too small and the length of time since treatment is too short for a fair evaluation of the method It is probable that they will be of little real value for this purpose They have been used with apparent success for the treatment of very superficial basal-cell epithelioma epecially of the upper eyelids.

the basal-cell layer or from similar cells in the epithelial layer of the cutaneous appendages Under the microscope in addition to finger like down-growths of the epidermis it is seen that some of the cells become more or less keratinized thus forming the characteristic whorls or pearl like bodies Tissue reaction is not so marked as in basal-cell epithelioma.

Occurrence.—Squamous-cell epithelioma occurs about half as frequently as does basal-cell epithelioma They develop most frequently in the mucous membranes of the lip and mouth They are seen less frequently on the penis vulva eyelids and nose When occurring in

FIG. 54.—Squamous-cell epitheli ma of rim of right ear Not senile keratoses on face.

the skin the most common locations are the scalp dorsal surfaces of the hands, and the ear Probably in the majority of cases the malig nant growth is preceded by one of the so-called precancerous condi tions, especially senile keratosis and leukoplakia The majority of patients are over 35 years of age Carcinoma of the tongue is relatively uncommon in women Statistics show that the affection is about three times more common in males than in females

Clinical Characteristics.—The lesion may begin as an ulcer or as a nodule Ulcers are usually indurated Nodules continue to grow in size to form a tumor which may be hard or soft and which as a rule

Fig. 51 —Basal-squamous-cell epithelioma. Originally diagnosed as tuberculosis and ring finger amputated. Epithelioma is present in the scar There is an epithelioma on the flexor surface of forearm. Epithelioma developed in the axillary glands, and the arm was amputated. Case reported by Henry D Niles (Metastasis of a basal cell epithelioma, Am. J Cancer Vol 15 July 1931)

Fig. 53 —Same as Fig. 51 After amputation.

and perhaps even a day may mean the difference between life and death.

As a rule metastasis occurs in the regional lymphatics but not in frequently the first evidence of metastasis consists of a tumor of the bones or some organ

Occasionally carcinoma attacks the skin secondarily from a focus in some other organ. An example of such secondary invasion is cancer *en cuirasse*

Prognosis.—Squamous-cell epithelioma is a very serious affection and even in favorable cases the prognosis must be guarded. It is of the utmost importance to detect the lesion establish a microscopic diagnosis and completely remove or destroy the lesion while it is still local. Of course there is no way of knowing how early metastasis

FIG. 56—Squamous-cell epithelioma of left ring finger

may occur but when the lesion as revealed by the microscope shows an *intact basal-cell lining* no *finger-like processes and no invasiveness* it is probable that metastasis has not yet occurred.

Based on cytology squamous-cell epitheliomas are of four recog nized grades of malignancy Clinical dermatologists recognize several grades of malignancy based on clinical features. As we have seen when the lesion develops in sclerotic tissue as in lupus interstitial glossitis scars x ray skin and in some keratoses and some cases of leukoplakia and kraurosis evolution is likely to be slow and metastasis delayed Epithelioma developing in an apparently normal tongue is apt to be rapidly invasive On the whole the evolution of squamous-cell epithelioma of the apparently normal skin is not particularly rapid but occasionally a lesion will appear suddenly in apparently normal skin or membrane invasion of neighboring tissue being rapid and metastasis occurring very early

is opaque rather than semitranslucent as in basal-cell epithelioma. Nodules and tumors often ulcerate Not infrequently the lesion is ver rucous, vegetating or papillomatous As a rule there is but a single lesion. Occasionally there are several When occurring in scar tissue, or similar tissue and when of a comparatively low grade of malig nancy the growth may be slow and metastasis delayed. As a rule, however evolution is rapid and metastasis occurs early

The lesion is always sharply defined and usually indurated. The disease invades practically all tissues—connective tissue cartilage, periosteum bone, viscera, lymphatic system etc.

FIG 55 —Same as Fig. 54. After removal with cutting current.

The affection must be differentiated from syphilis tuberculosis, basal-cell epithelioma and a number of other conditions A dermatologist can usually make a fairly accurate clinical differentiation but the proper way to avoid diagnostic error is by microscopic examination

It often happens in cases of tongue cancer in a syphilitic patient that the physician will waste valuable time with the so-called thera peutic test that is he will administer intensive antisyphilitic treat ment over a period of several months In all such cases it is advisable to make a microscopic examination at once It is important to keep in mind that squamous-cell epithelioma is so serious that a month, a week

these cells would have to differentiate slightly before they reached a state that compared favorably with the normal basal cells

Melanocarcinoma arises from cells which have undergone marked dedifferentiation These cells would have to differentiate to a great extent before they reached a biologic state of development comparable to that of normal cells

Since cellular differentiation plays such an important part in the grading of malignancies it is important for the microscopist to be familiar with any deviation of the cellular structure from the normal.

In the grading of malignant neoplasms the proportion of cells that are differentiated is compared to those cells which are undifferentiated. The results are expressed thus

Grade 1 Carcinoma The proportion of differentiated cells ranges from almost 100 down to 75 per cent that of the undifferentiated cells from practically 0 up to 25 per cent

Grade 2 Carcinoma The proportion of differentiated cells ranges from 75 down to 50 per cent that of undifferentiated cells, from 25 up to 50 per cent.

Grade 3 Carcinoma The proportion of differentiated cells ranges from 50 down to 25 per cent that of undifferentiated cells from 50 up to 75 per cent.

Grade 4 Carcinoma The proportion of differentiated cells is from 25 per cent to practically 0 that of undifferentiated cells from 75 to 100 per cent.

For a more detailed explanation on the grading of malignancies the reader is referred to Broders articles on the subject.

Treatment.—For lesions that are microscopically diagnosed before they become invasive and probably before metastasis has occurred excision with scalpel or the cutting current would seem to be the method of election When we encounter a small lesion that we think is or might be epithelioma of the squamous-cell type we excise it with a scalpel If it cannot be excised in this manner it is done with the cutting current. Naturally the excision is wide and deep A careful histologic study is then made to establish diagnosis to determine the grade of malignancy to ascertain the degree of invasiveness if any and the probability of metastasis already having occurred and finally to determine whether or not all malignant tissue has been removed. Subsequent treatment depends naturally on the result of the examination. When there is no or very little invasion and the malignant cells are well within the excision no additional treatment is given but the patient remains under observation. When in doubt, roentgen rays or radium is employed

Advanced cases may be treated with roentgen rays or radium with surgical diathermy or scalpel surgery or with a combination of these methods according to location extent of involvement grade of

Broders'[20] classification explains the difference in the malignancy of the same type of carcinoma in different situations The grading of malignancies is based upon cellular differentiation A dedifferentiated cell is one in which the functioning quality is decreased or absent and the reproductive or proliferative quality is increased The basal-cell type of carcinoma shows that dedifferentiation is slight, therefore

Fig. 57.—Squamous-cell epithelioma of lower lip

Fig. 58.—Same as Fig. 57 After surgical diathermy

Fig. 59.—Squamous-cell epithelioma of lower lip

Fig. 60.—Same as Fig. 59 After surgical diathermy

mucous membrane. The second stage includes more extensive lesions with infiltration of the subcutaneous structures but not affecting the lymphatics The third stage includes those cases having lymph gland involvement. All these cases were treated with roentgen rays alone.

One hundred and eight patients were in the first and second stages Four of these showed glandular metastasis at a later date and died Eleven of the cases were in group three and all died Roentgenotherapy

Fig. 65.—Verrucous squamous-cell epithelioma of lower lip involving left commissure

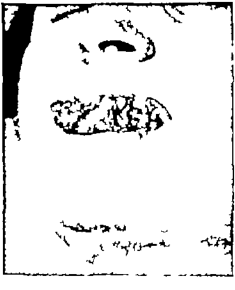

Fig. 66.—Squamous-cell epithelioma of tongue of a woman.

malignancy, etc. In this country excellent results have been obtained in cases of advanced carcinoma of skin and orificial mucous membranes by Clark, Pfahler,[21] Quick,[22] Wood Regaud [23] and others with com-

FIG. 61—Squamous-cell epithelioma of lower lip.

FIG 62—Same as Fig. 61 After removal with cutting current.

FIG. 63—Squamous-cell epithelioma of lower lip

FIG. 64—Same as Fig 63 After removal with cutting current.

binations of roentgen rays radium, surgical diathermy and scalpel surgery

In a recent article Martin [24] reports on 119 cases of squamous-cell epithelioma of the mouth and lips These he classifies in three clinical stages In the first stage are those cases involving only the skin and

Quick reports 2 741 cases treated over a period of 10 years from 1917 to 1927 Twenty-one per cent are known to be clinically free from gross evidence of disease 11.8 per cent of the entire group have been free from clinical evidence of disease for periods of three to ten years

In this period of ten years 473 tongue cases were treated 105 are free from clinical evidence of disease 53 being beyond the three-year period and 32 beyond the five year period

Regaud [22] treated 344 cases of cancer of the tongue and floor of the mouth at the Radium Institute in Paris during a period of six years

FIG. 69—Aphthous ulcer resembling epithelioma

(1920-1926) Eighty two of these or 23 8 per cent, were completely cured. The method used was the implantation of radon in removable platinum-iridium needles—the so-called radium puncture If the glands of the neck were involved and proved to be carcinomatous histologically then a block dissection was resorted to with the application of a radium pack at a distance of 5 to 8 cm. from the skin surface Regaud is of the opinion that distance radiation with a radium pack or a wax mold will supplant the radium puncture method in the treatment of primary carcinomas By using this method in the treatment of carcinoma of the lip he reports the following results

A. Operable Cases 98 per cent cures of the primary localization 92 per cent cures of cases with cancerous adenopathy (operable cases with glands)

failed to cure all the cases having glandular involvement whether or not they were clinically present.

The treatment is directed toward complete destruction of the local lesion and irradiation of the glands draining the involved area. Complete destruction may be accomplished by surgery high frequency currents or by radium or roentgen rays

It can be said that there is no method of choice for the treatment of prickle-cell carcinoma. Frequently the best treatment is a combination treatment of surgical removal and application of roentgen rays or gamma rays of radium. For more detailed statistics and methods of treating cutaneous malignancies see textbook by MacKee [18] and monograph by MacKee and Cipollaro [24]

When carcinoma of the lip or mouth has invaded the cervical glands, Quick [22] treats the neck from both sides with heavily filtered radiation

FIG. 67.—Squamous-cell epithelioma of tongue.

FIG. 68.—Same as Fig. 67 After removal with cutting current.

of maximum intensity consistent with tissue tolerance Radium is preferred to roentgen rays but if sufficient radium element or radon is not available then heavily filtered high voltage roentgen rays should be used for it is better to give a good dose of roentgen rays than a poor dose of radium. If only one node is involved and the carcinoma has not invaded the capsule that node is removed surgically If after irradiation there is a palpable node then a unilateral block dissection is indicated After dissection filtered radon seeds are placed in suspicious places before the wound is closed If the involvement is so extensive in the glands that the case is inoperable then filtered radon seeds are placed throughout the cancer-bearing area. For all practical purposes it can be said that when cancer involves the glands on both sides of the neck the case is inoperable and hopeless Heavily filtered roentgen ray therapy may be used palliatively

TRANSITIONAL-CELL CARCINOMA

This type of tumor arises from tissues having abundant squamous-cell tissue as for example the tongue floor of the mouth, tonsils sinuses ducts of mucous glands etc.

The rapidly growing forms of these lesions are difficult to recognize microscopically Quoting from Ewing [25] these tumors 'probably spring from gland ducts but may also arise from the general stratified layer of cells lining mucous surfaces. They form sheets of rather small cells which are cuboidal or spindle-shaped They excite little growth of connective tissue For these reasons they are markedly radiosensitive

The primary lesion is usually very small and metastasis is likely to occur early in the adjacent glands. The surface is finely granular and flat, giving the appearance of an erosion rather than an ulcer Clinical evidence of infiltration is usually absent This lesion is so small that it is frequently overlooked and the first evidence of its presence to be noted by the patient may be glandular enlargement.

In the treatment of this type of malignancy the importance of a biopsy must be stressed If the microscopic examination shows a transitional-cell epidermoid carcinoma then the best treatment is radiotherapy combined with surgery Gold radon seeds may be implanted in the tissues surrounding the primary lesion after its removal with surgical diathermy Metastatic glands are treated with heavily filtered roentgen rays or radium.

PAGET'S DISEASE

Darier [26] Pautrier [3] Fraser [4] and others have made careful studies of Paget's disease of the nipple As a result of these investigations while there is no unanimity of opinion the consensus is that Paget's disease of the nipple is a carcinoma of the intra-epidermal portion of the mammary duct also that Paget's disease is cancer from the very beginning. The distinctive microscopic picture includes the so-called Paget cell. These are sharply defined large epithelial cells which contain a single large deeply stained nucleus

Paget's disease of the nipple occurs rarely in men Most of the cases occur in women. It is an uncommon rather than a rare disease Both breasts may be attacked. It seldom occurs before the age of 35 Evolution is slow but sooner or later there is evident carcinoma of the breast with metastasis to the axillary glands

The clinical picture is not always the same. The usual picture is that of a sharply marginated eczema surrounding the nipple The eruption however does not yield to any of the therapeutic agents employed for eczema, including small doses of roentgen rays The stubbornness location age of the patient sex, sharp margin persistent erosions

B Cases of doubtful operability including those with glandular metastasis, 72 per cent cures.
C Inoperable Cases 17 8 per cent cures of the primary localization considered by itself, 14 2 per cent cures of both primary and metastatic lesions

Carcinoma of the penis is always of the squamous-cell type. It is found to be more prevalent among those who have not been circumcised in childhood A tight prepuce is considered by some to be an important etiologic agent. Of all cancers in the male, 1 to 3 per cent are those of the penis When these lesions are treated early they respond well to roentgen rays and radium The vast majority however do not seek expert advice until after the disease is quite advanced with involvement of the deep tissues and inguinal glands

Pfahler and Widmann [21] report nine cures of ten cases treated. Their method consisted, in the majority of cases, of amputation of the penis by surgical diathermy and the application of roentgen rays to the inguinal glands In some cases amputation was preceded by irradiation These results excel those obtained by surgery alone.

Some cancer experts prefer to administer a large dose of roentgen rays or radium to a tumor before the lesion is removed or destroyed with scalpel surgery or surgical diathermy especially when there is no evidence of metastasis The rationale of such procedure is that any cells that remain *in situ* or that may enter the blood stream or lymphatic channels have received a dose of radiation that may prove lethal or that will at least be inhibitory The idea is a good one, but there are no convincing statistics in support of the method.

The dose either of roentgen rays or of radium must, of course, be decided and administered by an expert. Experience has demonstrated the fallacy of producing extensive third degree reactions In many instances the dose may be well within tissue toleration In other instances the dose must be very close to the limits of toleration. With roentgen rays the dose ranges from a few times to many times that required for erythema depending on the size of the area treated the age of the patient and particularly the quality of the radiation i.e. the voltage and amount of filtration. With radium and radon packs (distant treatment) the dose ranges from a few hundred to several or many thousand milligram or millicurie hours. The dose depends on the character of the lesion and the dimensions of the surface to be exposed the amount of filtration and the distance between the pack and the skin or mucous membrane When gold or platinum radon seeds or implants are employed, it is customary to implant one seed for every square centimeter of tissue. They are implanted all through the lesion and around its periphery The amount of radon in each seed varies from 0 75 millicurie to 1 5 or 2 millicuries

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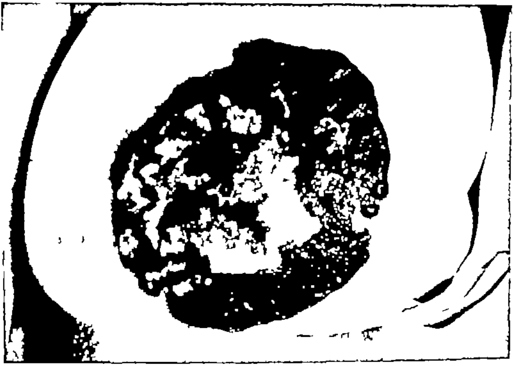

FIG. 70.—Paget's disease of the nipple.

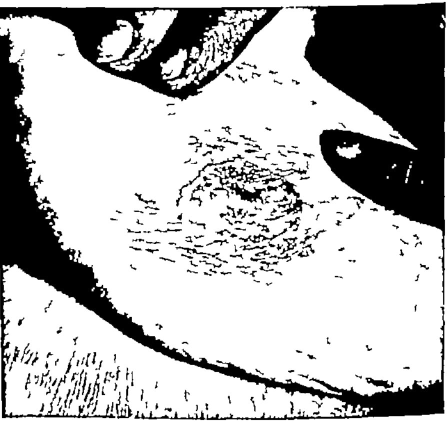

FIG 71 —Pa disease of the nipple (Courtesy of Dr Josiah P Thornley.)

infiltration retraction of nipple and perhaps some pain should make one suspicious of the true nature of the affection Instead of an eczema like eruption the condition may consist of infiltration of the nipple or the nipple may be keratotic or verrucous and is usually retracted It is unwise to depend on clinical diagnosis When a nipple or a breast has been normal and becomes abnormal and the condition does not respond immediately to conventional treatment, a careful microscopic study of the tissue should be made

Treatment.—Cases have been permanently cured with roentgen rays and radium but such treatment is uncertain It is now the con sensus of opinion among dermatologists that as soon as the diagnosis is established mastectomy with removal of axillary glands should be performed

EXTRAMAMMARY PAGET'S DISEASE —Paget s disease has occurred on the penis scrotum, perineum, pubic region umbilicus lip nose cheek, forearms trunk ears and tongue In fact it may occur in almost any location In such instances the growth begins in the epithelium associated with the cutaneous appendages Clinically extra mammary Paget s disease may resemble Bowen s disease eczema, psoriasis, basal-cell epithelioma squamous-cell epithelioma and other diseases. As a rule the diagnosis can be established by microscopic examination

Treatment consists of removal or destruction of the lesion with surgical diathermy or scalpel surgery

FIG. 72 —Bowen's disease.

BOWEN'S DISEASE

Originally, this condition was thought to be a forerunner of cancer It was known as Bowen s precancerous dermatosis It is now known to be cancer from the beginning—an intra-epidermal carcinoma. There may be a single lesion or multiple lesions They are most common on the trunk and extremities but may occur in almost any location, even in the orificial mucous membranes Clinically, they resemble the flat type of basal-cell epithelioma—multiple epitheliomatosis cutis They have a well-defined margin and a dark red color They may be dry and scaly or edematous exudative and eroded. As a rule, there is very little infiltration, especially in the early stages Evolution is slow and the degree of malignancy is low Metastasis does not occur Clinically, the affection must be differentiated from basal-cell epithelioma squamous-cell epithelioma, eczema, psoriasis, and other dermatoses. The disease can be cured with roentgen rays radium or with electrodesiccation.

FIG. 73 —Melanoma in a young boy

MELANOMA

The term *melanoma* is ordinarily used to designate a pigmented malignant neoplasm. Benign melanomas include pigmented nevi the blue nevus of Tièche and the mongolian spot, while malignant melanomas include melanocarcinoma, nevocarcinoma melanosarcoma and nevosarcoma. Melanomas probably all arise from a specific mesoblastic cell the chromatophore. The term *melanosarcoma* has been used incorrectly as a synonym for melanocarcinoma. Melanosarcomas are rare and arise in the chorold coat of the eye and in the blue nevus of Tièche [264a]

Fig. 74.—Melanoma of the hand.

Fig. 75.—Melanoma of scalp.

FIG. 76.—Melanoma of ear resembling epithelioma.

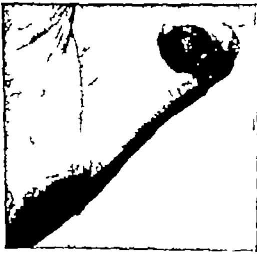

FIG. 77.—Melanoma of thumb—melanotic whitlow

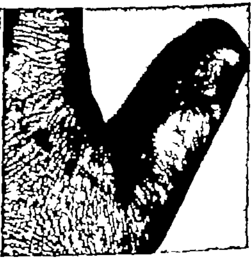

FIG. 78.—Same as Fig. 77 After surgical and roentgen ray treatment.

FIG. 79.—Melanoma with metastasis.

FIG. 80.—Melanoma of scalp

The type of nevus that most frequently gives rise to melanoma is the blue-black or slate-colored, smooth flat, hairless mole. Metastasis is likely to occur early The prognosis is grave Melanomas may occur at almost any age Occasionally such an innocent condition as granu loma pyogenicum may markedly resemble a melanoma

Lesions of this type have been cured with roentgen rays and with radium, but such treatment is very uncertain, as melanoma is radio-

FIG. 81—Granuloma pyogenicum resembling melanoma.

resistant Perhaps the best treatment consists of the administration of a large dose of heavily filtered radium or roentgen rays followed by excision with the cutting current. Malignant cells may be found some distance from the periphery of the lesion especially in the subcutaneous tissue Therefore the excision should be wide at the surface and wider below—cone-shaped excision It should extend down at least to the muscle The excised tissue should then be carefully examined under the microscope to ascertain so far as possible whether or not all the malignant cells have been removed When diagnosed before metastasis has oc ırred and before there has been much local spread

ing it is possible to obtain a permanent cure. After metastasis has occurred very little can be done Metastatic lesions soon occur in the viscera and various parts of the cutaneous surface

SARCOMA

Sarcomas of the skin are the least common of the cutaneous malig nant neoplasms They are formed of immature connective tissue cells In the *nonpigmented tumors the cells may* be of the small or large round variety spindle-shaped or the mixed-cell type The small round cell sarcomas are the most malignant and the fibrosarcomas and giant cell sarcomas the least malignant The more the cellular structure resembles adult tissue the less the malignancy

The following classification of cutaneous sarcoma has been sug gested by De Amicis [27]

1. Localized or multiple nonpigmented sarcoma.
2. Melanotic sarcoma
3. Multiple hemorrhagic sarcoma of Kaposi.

Localized Nonpigmented Sarcoma —This variety is the most benign. It appears as a single localized tumor pea to lemon sized usually the color of normal skin Early surgical removal offers the best outlook.

Multiple Nonpigmented Sarcoma.—In this type the lesions vary in number from a few to several hundred These lesions may develop following the appearance of a single primary growth. They are pin head to egg-sized and are round or oval The overlying epidermis is smooth and shiny and telangiectases are frequently present The out look is serious Coley's serum may be tried but it is doubtful if any benefit can be derived from it. Roentgen rays may be used pal liatively

Melanotic Sarcoma.—This is the most malignant of the sarcomas Lesions usually start in the choroid layer of the eye or in the blue nevus of Tièche The cutaneous lesions are pinhead to egg-sized of a firm consistency and blackish in color The shape is oval or round and slightly elevated. These cases end fatally practically always unless detected very early Coley's serum may be attempted Little can be done except in a palliative way

Multiple Hemorrhagic Sarcoma of Kaposi.—This affection is not very malignant. The sites of predilection are the extremities It occurs most frequently in males The eruption consists of various-sized, infiltrated, lilac-colored doughy plaques or collections of several

The type of nevus that most frequently gives rise to melanoma is the blue-black or slate-colored smooth flat, hairless mole. Metastasis is likely to occur early The prognosis is grave. Melanomas may occur at almost any age. Occasionally such an innocent condition as granuloma pyogenicum may markedly resemble a melanoma.

Lesions of this type have been cured with roentgen rays and with radium, but such treatment is very uncertain, as melanoma is radio-

Fig. 8 —Granuloma pyogenicum resembling melanoma.

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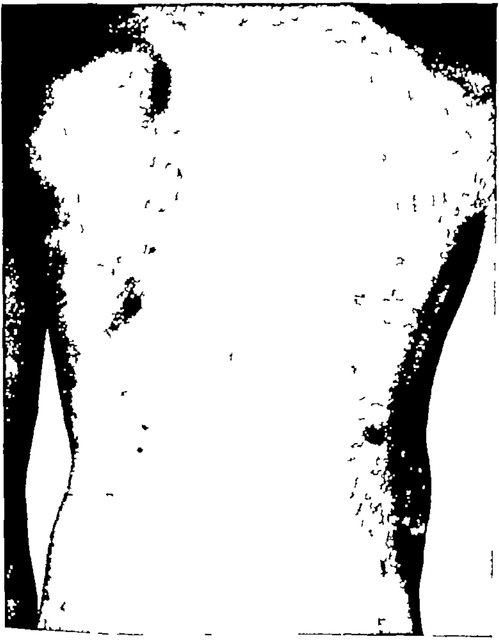

FIG 85 —Multiple lymphosarcomas.

Fig. 82.—Lymphosarcoma

Fig. 83.—Same as Fig. 82. After removal with cutting current by Dr. J. J. Eller

Fig. 84.—Lymphosarcoma of neck.

Fig. 86.—Giant-cell sarcoma

Fig. 87.—Same as Fig 86 After excision by Dr Merlin J Stone

Fig. 88.—Spindle-cell sarcoma

Fig. 89.—Same as Fig 88 After excision by Dr Merlin J Stone.

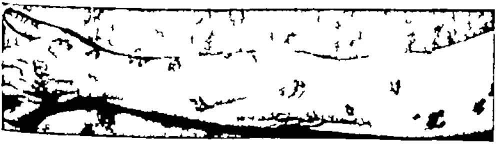

Fig. 90.—Sarcoma of Kaposi type.

or many firm, bean to pea-sized, reddish or purplish nodules Both types of lesions are usually present. Occasionally there is ulceration. Evolution is slow, the lesions persist for months and years spontaneous recovery may occur There is always danger of a rapidly growing more malignant type of sarcoma as a complication Roentgen rays are almost a specific for this disease Arsenotherapy is said to be of value (See article by MacKee and Cipollaro [27])

Neurogenic Sarcoma.—These are tumors arising from nerve tissue and may appear on any portion of the body They vary in size from that of a pea to an orange or larger The color is the same as that of the normal skin The prognosis is poor True neurogenic sarcomas have a high mortality and have a tendency to recur along the nerve trunk.

Dermatofibrosarcoma —Darier [28] reported four cases of dermatofibrosarcoma in 1924. Clinically, this condition is characterized by the development in the skin of small hard infiltrating nodules which increase in size and number slowly to form a dense sclerotic, bluish plaque Later on stalked, pedunculated or sessile nodules and tumors project from this plaque. These neoplasms are hard and may reach the size of an apple. The tumors are apt to recur after removal. Darier [28] gave this condition the name "progressive and recurring dermatofibrosarcoma.' It is asymptomatic, does not affect the general health and does not metastasize.

It is difficult accurately to classify these tumors histologically The picture is that of a fibromatous growth resembling very closely a spindle-cell sarcoma in certain cases

The tumors are radioresistant in fact, they do not respond to any form of therapy except as in the cases reported by Senear Andrews and Willis [29] in which there was no recurrence after complete excision of the mass.

Melanotic Whitlow (Melanoblastoma of the Nail Bed) —This is a malignant disease of the nail bed which is characterized by the formation of nodules of neoplastic tissue with associated formation of melanin about the border and beneath the nail. These lesions are painful and the majority of the victims die in from four to ten years.

Early surgical removal or amputation is the treatment of choice.

Lymphosarcoma —This condition usually arises in a single chain of lymph glands and occurs late in life Lymphosarcoma is very malignant and markedly susceptible to radiation The glands most frequently involved are the cervical and axillary glands. If neglected these go on to ulceration

Since this disease is radiosensitive, roentgen rays and radium are indicated. In some cases isolated involved glands may be removed surgically

FIG. 92.—Mycosis fungoides.

Fig. 91.—Sarcoma of Kaposi type.

FIG. 91—Mycosis fungoides.

Fig. 91 —Sarcoma of Kaposi type.

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Fig 93.—Lymphoblastoma.

Miscellaneous Malignant Diseases.—The Spiegler Fendt sarcoid is thought by some to be a benign type of sarcoma. Serious diseases of the hematopoietic system and reticulo-endothelial system may cause tumors of the skin—leukemia cutis Hodgkin's disease, mycosis fungoides lymphoblastoma etc. Many such conditions are temporarily amenable to roentgen-ray and radium therapy

CHAPTER NINETEEN

ELECTROSURGICAL CURRENTS AND THE HISTOLOGY OF ELECTROSURGICAL WOUNDS

JOHN D ELLIS M.D

For surgical purposes a high frequency current is an oscillating current having a rate of frequency above the threshold which produces faradic response due to conduction of the current into the tissues Its virtue lies in the effects resulting from the resistance of the tissues to the current, which manifests itself in the formation of heat and the local destruction of tissues of various and peculiar types

It is my purpose to deal with a distinction in effect upon tissues of the so-called cutting current and the coagulating current in so far as such distinction can be made and in a rudimentary way with the distinction in the quality of the current which produces the cutting and coagulating effects The production technic, and tissue effects of fulgurating and dehydrating currents will be more briefly described. The commercial machines produced by different manufacturers vary greatly in construction and produce a correspondingly great variety in the quality of current The ohmic resistance is often too great or too little to give the desired effect and undesirable secondary faradic currents with their resultant neuromuscular response are experienced when improperly constructed machines are used For example it appears that the only way in which the sustained oscillating current of radiotron machines can be employed for coagulating purposes is by raising the amperage and voltage to a point where charring of the tissues which prevents a dissemination of the coagulating effect, soon results On the other hand the spark-gap machine produces a current from which it is difficult to eliminate the coagulating effect of the damped current inherent in the spark-gap machine The present lack of standardization is unavoidable because of the difficulty in accurately measuring amperage or voltage during operation of the machine so that the proper strength of current used for coagulation or for cutting must be learned by experience with each individual machine

A very nice balance must be maintained between voltage and amperage and also the capacity inductance and resistance must enter into the determination of the particular current used

Doyen's earliest machine producing a high voltage and high frequency of oscillations but a low amperage was equipped with a transformer, spark gap and condenser attached in circuit with an Oudin

therefore undamped oscillations The oscillating currents from radiotron machines present a precisely determined wavelength. In contrast to this the oscillations of the spark-gap machines are composed of a mixture of waves of different lengths It is not to be supposed that in actual practice damping is the only factor which distinguishes the cutting from the coagulating current. The elevation of both amperage and voltage within certain limits produces more coagulation, while the increase in frequency in the undamped current up to a certain optimum of several million per second tends to produce a more smooth and uniform cutting effect. The duration of the application of current to tissues and the density of current as conditioned by the size and shape of the active electrode or cutting point also function in the determination of the extent of the area of coagulation By lowering the voltage of the coagulating current to a minimum the slow heating effect on tissue produces what Clark called electrodesiccation a dehydrating change without electrocoagulation

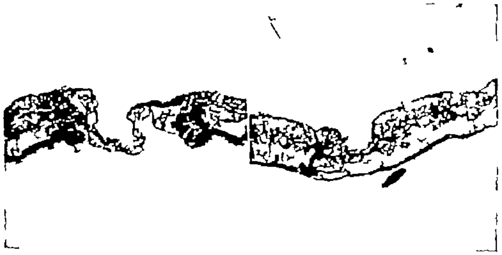

FIG. 1—Skin of frog incised with a minimum amount of cutting current presenting section with a thin layer of coagulation such as would not be expected to prevent primary union.

FIG. 2—Frog skin divided with a dehydrating current. The epidermal cells adjacent to the cut are changed in orientation x 36 5

General Effects of the Cutting Current on Tissues

The technic of electrical cutting is the most recent development in electrical surgery Smooth cutting depends in part upon the frequency of the oscillations and upon the adjustment of a spark-gap machine to a frequency of 50,000 to 80 000 while with a radiotron machine exhibiting a frequency of often more than 1,000,000 the knife electrode can be handled just as a plain scalpel The electrode glides through the tissues without the necessity of pressure One has

coil Later he used the entire solenoid (Oudin coil) as a secondary coil, taking the current off at both ends, producing the so-called biterminal current. The earlier machine supplied a fulguration cur rent, while the later one furnished the current we now call electro-coagulating Charring of tissues in fulguration prevents penetration of the coagulating effect.

The Cutting Current

The production of the cutting current came many years later, and is just now being widely discussed in German literature by Kuecken and Doederlein in the Gynecological Clinic of the University of Munich, and by Keysser a former associate of Lexer The principal French contributors are Champy and Heitz Boyer, while in England some experimental work has been undertaken in London by Sampson Handley, Gordon Taylor, and Douglas Harmer In America, several important surgeons are now interested in the possibilities of the cut ting current.

This cutting current depends for its peculiar surgical effects and characteristic tissue changes upon the amount of damping—or rather lack of damping—of its wave trains It is safe to say that the more nearly a perfect, sustained uninterrupted oscillation is exhibited the more nearly the wound produced approximates that of a surgical scalpel. The exact wave forms produced by the various surgical ma chines during their application have not yet been actually photographed with a cathode ray oscilloscope because of technical difficulties in projecting the shadows of the individual wave of oscillations at such high frequency as the ones now used and because these oscillations are affected by various adventitious factors of damping and second arily induced wave forms

The production of a high frequency surgical current depends upon the oscillation of electrons which perform a pendulum-like move-ment. There are two fundamentally different methods of obtaining these oscillations In the first just as the swinging of a pendulum gets smaller and smaller on account of the friction resistance so in the spark-gap machine the oscillations of the electrons slowly decrease, because in the spark gap they are damped by air resistance We deal therefore, in spark-gap machines with damped high frequency oscil lations In the second method, undamped oscillations are generated by means of radiotrons. These machines employ the same radiotrons or radio tubes which are used in the wireless and in broadcasting We know that in radiotrons a pure current of electrons is flowing which is rhythmically influenced by the continually changing charge of the grid between the anode and the cathode in the tube. This is the mechanism by which sustained oscillations are generated. Since the radiotron is evacuated as far as possible—that is free from air—the oscillations are not damped by air resistance of any kind and are,

The Dehydrating Cut

By a slight change in voltage and amperage a cutting current can be reduced with enough coagulating characteristics to seal the smaller blood vessels along the edge of the cut in an area of so-called dehydration, which is white and presents cells with shrunken contour and pyknotic nuclei the fluid contents having evaporated The skeleton contour of the cells is distinguishable The cytoplasm stains vividly, while the nuclei are hyperchromatic.

General Effects of the Coagulating Current on the Tissues

This tissue effect is produced par excellence by a high amperage and a strongly damped current in a spark-gap machine or by raising the voltage and amperage of the radiotron machine A lower frequency of oscillations is necessary than for cutting purposes Widespread coagulation can easily be produced with a spark gap machine without charring or carbonification of the edges of the wound (Fig 3) In the use of this as in the cutting current, the electrode is brought in contact with the tissues and then the circuit is closed If the circuit is closed before the contact is made sparking across from the electrode to the tissues may result in charring This zone of charring interferes with the dissemination of the coagulating current and limits the coagulating effect It is also improper to remove the electrode from the tissues until the current is opened. This sparking from the electrode to the tissues besides the charring effect also induces faradic extra currents and muscle jerking which interfere with the delicacy of the operation Small areas of coagulation assume the form of a half globe or an inverted cone the base of which is on the surface of the tissue being cut. Two definite zones can be described in the coagulating effect. The inner zone is blanched and the zone external to this is hyperemic in appearance. The inner zone in histologic preparations presents a blue nuclear staining, e g hematoxylin contrasting with the red eosin staining of the intact tissue The tissues so affected are somewhat shrunken and the nuclei have lost their definition and stain poorly or disappear This is the typical picture of coagulation necrosis The proteins are split, freeing blue staining acid radicals with a probable increase in the local hydrogen potential. According to Doederlein the protein hydrosol is changed into a hydrogel This inner zone passes over into an ill-defined outer zone of shriveled cells with pyknotic nuclei and a region of dilated vessels The faster the tissue dies the more it conserves its original form and shape (Ernest) The primary effect of the heat is identical with necrosis of ordinary skin burns This applies to preparations made immediately after the operation Preparations made several hours or days later show the outer zone being invaded by fibroblasts round-cell accumulation and for

the impression that the tissue melts under the influence of the electrical current. Kirschner, for this reason, has given it the name of "melting cut." This incision has the gross appearance of a scalpel cut (Figs 1 and 2) Kelly has called this procedure "acusection" and Keysser has described it as 'akutomy The histologic effects on tissues can be described in zones the innermost being a zone of mechanical disruption of tissue and explosion of cells The question of whether this effect is produced by molecular dissonation, due to the assumption by the molecules or atoms of the tissues of a new rate of vibration, causing dissolution of the molecular structure, as postulated by Oudin, or whether it is merely a thermal effect due to the sudden expansion of the cell when its liquid contents are converted to steam, as Jellinek thought, is speculative and need not interest us here Just outside of this zone of tissue disappearance is a zone of elongation or attenuation of cells, this drawing-out effect being seen principally in the nuclei which are more fluid than the cytoplasm. Kawamura described radiating lines of similarly attenuated cells running out from areas of electrical injury in fatal cases. Depending upon the fluidity of the tissues, there is a varying amount of change in the orientation of these elongated cells so that they come to lie parallel with the direction of the cut. This effect is seen at its maximum in soft connective tissue or muscle, and cannot be produced in the stratum corneum of the skin In parenchymatous organs, this elongation is transmitted along the nearby blood vessels perhaps because the tissue surrounding the vessels is less resistant than the vessel wall itself

Wildermuth, assuming the resistance of a chemically pure physiologic salt solution of a temperature of 18 C (64.4 F) as 1 estimates the specific resistance of the various tissues as follows

Fatty tissue	19.4
Brain tissue	5 5– 6 8
Pulmonary tissue	3 5– 4.0
Liver tissue	2.8– 3 3
Skin	2 5– 3 0
Muscle	1.2– 1 5
Blood approximately	1 0

The higher the fluid or blood content of an organ and the lower its fat content the less its resistance to electric section. The great resistance in cutting through fat, as compared to muscle and skin at first disturbs the surgeon habituated to the scalpel which cuts fat more readily than muscle and skin The variation of resistance to electric cutting necessitates a readjustment of the machine as one passes from s n into fat, and then into muscle or parenchymatous organ

The Dehydrating Cut

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eign body giant-cell formations Robertson and Boyd have isolated from the tissues coagulated by heat two immunologically specific toxic proteins One, diffusible and thermostable, they term a 'neurotoxin" and the other thermolabile and colloidal a "necrotoxin' Pfeiffer, and Becky and Schmitz have isolated a toxic protein from the urine.

FIG. 3.—Dog skin to which has been applied an electrode bearing the least amount f cutting current which would leave a visible mark on the surface. A wide wedge of necrosis results with less current than is required to sever the skin. Fragmentation of a hair is seen. Vacuolization appears in the corium; x 65

It is probable that these toxins produce the outer area of secondary necrosis

Nieden has pointed out that deep coagulation even in the inner zone of complete necrosis is always uneven. In experiments in association with the physicist Weiss he tried to account for the unevenness and the direction of penetration according to the distribution of stream line[illegible] [illegible]oduced by different shapes of electrodes and marked variation of r[illegible]istance displayed by the various tissues This variation makes the d[illegible]ection of penetration and deep coagulation unpredict

able, and the resulting tissue injury one of the most dangerous factors one deals with in electrosurgery After coagulation in the vicinity of large vessels a fatal postoperative hemorrhage may occur as the result of an unexpected necrosis of the vessel wall.

Specific Effects on Different Tissues

Skin preparations were first studied in our experiments to determine the type of injury produced by the minimum amount of cutting and coagulating current which would leave a visible impression on the surface. Later attempts were made to incise the skin of the human

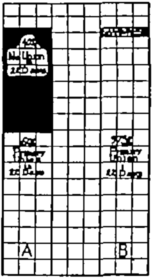

Fig. 4—Comparison f primary unions between electrosurgical knife wounds, *A* and scalpel control wounds, *B* (Reprinted from J.A.M.A. 96 6–18, 1931)

dog rabbit and frog with a current producing a purely cutting effect without necrosis In all skin possessed of a stratum corneum i.e in all types employed except that of the frog specific cutting effect without coagulation could not be accomplished A narrow margin of coagulation bounded every incision although this was narrower (a minimum of 1 mm.) with the cutting than with the coagulating current. The stratum corneum then resists the disruptive effect of the cutting current until enough heat is produced by tissue resistance to cause coagulation. At the time of incision the epidermis is blanched and is thinner because it is shrunken The individual epithelial cells can no longer be discerned plainly in the stratum corneum, while in the strata mucosa and germinativa, the cells assume somewhat the appearance of those in a normal corneous layer The cells in the basal layers are shrunken together and have dark spindly nuclei The fibers of the connective tissues of the corium are either coagulated adjacent

to the cut or have lost their fibrillary structure and appear as conglomerate masses, often resembling hyalin in appearance. They can no longer be dyed red in a hematoxylin-eosin preparation, but turn slightly blue Between these close-pressed masses appear shrunken nuclei When the cut reaches into the fat, only the connective tissue of the fat is changed, the fibers being broadened, dyed blue, and con

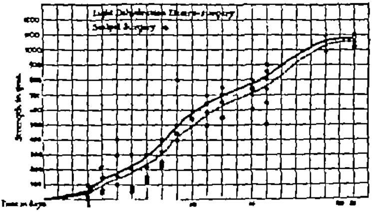

FIG. 5—Tensile strength of wound healing in skin of dogs The strength of healing never varies more than 100 Gm average between the scalpel wound and the electrical wound. (Reprinted from J.A.M.A. 96 16-18, 1931)

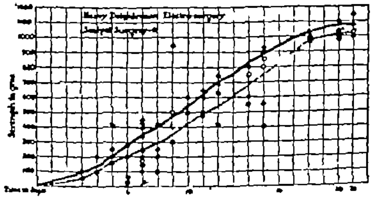

FIG. 6—The tensile strength of wound healing in skin of dogs. The strength of healing is less when heavy dehydration (or electrodesiccation) is applied than when slight dehydration is used, as in Fig. 5 (Reprinted from J.A.M.A. 96 16-18, 1931)

taining pyknotic nuclei In the stratum reticulare of the corium, flattened gas bubbles appear Keysser and Schridde seem to be the first to describe this phenomenon and Schridde saw it also in the epidermis In the skin of the rabbit, connective-tissue changes extend around the sweat glands at some distance from the region of the incision and the hairs are fragmented in the changed area around the cut.

The necrosi roduced by the minimum of coagulating and cutting current whicl vill leave a visible impression on the surface of all

the skins provided with a stratum corneum presents no difference in type of tissue injury from that of coagulation described above We conclude, then that it is not possible to produce a purely cutting effect without some necrosis on a skin with a horny layer This slight necrosis produced by the cutting current does not, however always preclude healing by primary intention as I found in another experiment performed to test the tensile strength of wound healing on dog skins. In this experiment 60 per cent of electrically produced wounds showed primary union in comparison with 97 5 per cent of primary

FIG. 7—Complete section of intestinal wall f dog with cutting current without necrosis 15 5

union in scalpel wounds (Fig 4) When union did occur however the electric wounds were somewhat weaker than the knife wounds until approximately the twenty fourth day of healing Figure 5 represents in a broken line the strength (expressed in Gm) of union of centimeter length cuts pulled apart with a tensiometer on different days of healing of dog skin This curve represents the 60 per cent of the electric cuts which healed by primary intention. The continuous line represents the 97 5 per cent of scalpel wounds.

It will be seen that in the mid-period of healing the electric wounds are notably weaker At 24 days the two curves have not yet approximated when heavy dehydration is employed (Fig 6)

The effects of the cutting current on skeletal muscles and the muscular wall of the stomach and intestines were studied Incisions may be freely made without any zone of coagulation whatever There are

a change of orientation and shape of the superficial cells and a sealing of the capillaries and lymphatic channels These incisions heal with approximately the same tensile strength as cuts made with a scalpel, and without secondary necrosis or infection (Fig. 7) Figure 8, representing tests on muscle section and healing shows no important weak

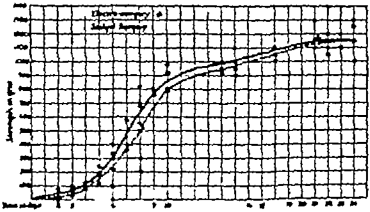

FIG. 8—Tensile strength of wound healing in muscle Incisions were made with very slight electrodesiccation the electrical incisions show almost the same strength of healing as the scalpel wounds. (Reprinted from J.A.M.A. 96 16-18, 1931)

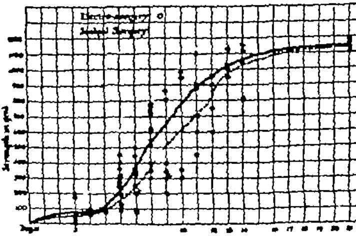

FIG. 9—Tensile strength of wound healing in stomach The middle values are decidedly weaker in the electrical incisions there is a wide variation in all the readings of dogs operated on (Reprinted from J.A.M.A. 96 16-18, 1931)

ness of the electrical wounds at any period of healing. Figure 9 a comparison in healing of electric and scalpel gastrotomy presents curves of healing for the electric wounds considered both as to rapidity and time of attainment of maximum strength, entirely comparable to the scalpel wounds of the muscle wall of the stomach.

Primary [illegible] dermal healing presupposes two factors, i.e., a deposition of a c[illegible]ete fibrillary fibrin across the wound and satisfactory

fibroplasia. Baitsell Hertzler and Hartwell have shown that fibrin and collagen are deposited in primary healing by a chemical reaction from prefibrin by the absorption of the edema fluid of a wound (Fig 10) This appears to them to be entirely independent of cellular activity and conditioned by the hydrogen potential of the wound Fibroplasia occurs first by stereotropism of wandering tissue cells or clasmatocytes along the fibrin network and later by proliferation of these cells producing fibroplasia. This mechanism was described in 1914 by Harrison, and the work has been studied and corroborated

FIG. 9.—Primary healing of stomach wall of dog without zone of necrosis after section with cutting current 3

recently by Baitsell Wereschinski and Carrel The last has shown that the formative stimulus to fibroplasia is not found in the blood plasma, but is a local product of the injured tissues Baker and Hammett, working in Carrel s laboratory found that the formative stimulus does not depend upon the amino acids that the wound or adjacent tissue contains but is a protein cleavage product containing a sulfhydryl group The elaboration of this essential stimulus for cell multiplication is apparently not interfered with by the application of the cutting current to muscle or stomach and in some instances to skin. The production of a fibrillary fibrin network is generally not demonstrable after electrosurgery Following the advice of Hertzler I attempted to demonstrate this network with a Weigert Pal stain, and later with the Kolschetzski modification but found only a granular fibrin deposition such as one sees in wounds healing by granulation

The coagulating current applied to skeletal muscles and stomach, produces the same inverted zone of coagulation as described in the deeper layers of the skin. The appearance of the coagulated muscle after a few days resembles hyalin in a necrotic area ultimately surrounded by a connective-tissue capsule or absorbed and replaced by fibrosis

Specific Effects on Blood Vessels

The discussion of the effects of these currents on the blood vascular system can be divided, for clinical purposes into

1 Capillary hemostasis in vessels of the size which do not usually bleed after the hemostat is removed in ordinary surgery e g., laparotomy wounds

2 The coagulation of moderate-sized vessels, such as the ones which must be ligated before the hemostat is removed

3 The closure of arteries and veins of the size of the radial artery or larger

Fig. 11—Electric ligation of vein with rupture of wall and extravasation of blood x 5.5

Hemostasis in Capillaries, Arterioles, and Venules.—When tissues are severed with the cutting current without any zone of coagulation capillary hemorrhage results (Fig 11) which suddenly ceases a few minutes later even in such vascular tissue or muscle or kidney with a facility that surprises the surgeon. This unusual effect was first investigated by Heitz Boyer who noticed in histologic preparations the transm ion of elongation and stretching of the cells of the peri

vascular sheath to a point several millimeters from the cut end of the capillary There is an abrupt change in the muscular wall of venules and arterioles, causing contraction and fusion with obliteration of the lumen at the point of severance. The arteriole in particular often becomes tortuous for a few millimeters (Fig 12) The vascular lumen is occluded by the collapsed walls and the few epithelial lining cells which are torn off and seen free in the lumen In some specimens no endothelial changes are seen except a curious wave like wrinkling in transverse ridges just at the point where the lumen begins to contract It did not appear to Heitz Boyer that the existence of a few avulsed cells in the lumen was sufficient to account for the sudden hemostasis

Fig. 12—Correct electrical collapse of arteriole × 30.

in the capillaries and arterioles after cutting and it was suspected that there must be a rapid and abundant liberation of thrombokinase from attrition of the vascular wall The following experiment was under taken The serum of rabbits' blood was placed in paraffined tubes Small well polished pipettes were introduced into rabbits veins and arteries without touching the edges of the wounds of entrance These vessels were then severed 1 to 2 cm from the pipette point with un damped current and with the scalpel The pipettes were withdrawn and placed in the tubes containing serum The pipettes from the vessels electrically damaged caused immediate coagulation of the serum while those from the vessels with the knife wounds caused no coagulation of serum for 10 to 12 min which is the same time that coagulation occurred in the control rabbit serum. They inferred from this that abundant thrombokinase was liberated from the smaller vessel walls by the action of the electric current

Electric Ligation of Small Vessels.—Vessels of a size which must be ligated to control hemorrhage in ordinary surgery are not generally successfully obliterated with a cutting current. Either they must be touched with a coagulating current or the hemostat which occludes them must be touched, in order to produce successful hemostasis. The less the tissue surrounding the vessel is gripped with the hemostat, the less the area of necrosis formed. The smaller the amount of necrotic tissue, the greater the chance of absorption of this tissue without a slough, and the less the chance of infection or secondary

Fig. 13—Correct "electrical ligation of artery Convolution of intima without desquamation at point of closure. The most notable changes seem to be displayed in muscularis and elastica x 29 5

hemorrhage from the coagulated vessel We experimented in coagulation of the splenic vessels and the radicals of the superior mesenteric vessels adjacent to the small gut in the dog and found that these were best occluded by use of the coagulating current (Fig 13) The walls present the same changes that occur in the capillaries on section. It is possible, however to exhibit enough coagulating current to break the vessel all into fragments and produce hemorrhage or to explode the brittle collapsed and constricted wall a few millimeters from the region of hemostasis As one becomes more efficient there is a temptation to employ more voltage and a shorter time This is dangerous. It is easy to generate a cloud of steam at the point of application which pushes in the vessel lumen exploding instead of sealing it. It is my opin that the successful coagulation depends upon the

mechanical effect of constriction of the lumen and not on thrombus formation The cells of the muscular layers appear crowded together and stained blue. There are the usual nuclear changes which accompany electric coagulation The intima is seldom avulsed and few free epithelial cells appear in the lumen (Fig 14) If the vessel is coagulated in the solid tissue of an organ the vessel change does not extend beyond the tissue necrosis in the parenchyma of the organ This limitation of change was first described by Kuntzen and Vogel who carried out experiments upon rabbits A lobe of the liver was fixed in

Fig. 14—Corrugations of intima, A with contraction of muscle walls in electrical hemostasis x 85

the abdominal wall and excised with a coagulating current The animals were killed on various days. The portal vein was injected with India ink. Thrombi were found to form only as far as the tissue necrosis in the surrounding liver substance An elective depth effect of the current upon blood vessels did not manifest itself beyond the region of coagulated liver No secondary hemorrhages occurred along the vessels. This agrees with my experience

Sealing of Larger Vessels.—Tinker has described the coagulation of the blood in these larger vessels extending 12½ mm. along the lumen. We were unable to demonstrate any such thrombosis in arteries In veins a definite coagulation extended not farther back than a

distance equal to the diameter of the lumen when the vessel was coagulated with a current strong enough firmly to close, but not entirely destroy the vessel Even after several days this small red thrombus was still seen in the vessel merely as a coagulation thrombosis the definition of many of the red cells being retained and the white cells appearing unchanged in morphology There is no progression in the size of the thrombus examined several days after the occlusion of the vessel According to Aschoff, this coagulation thrombosis is in sharp contradistinction to true thrombus formation, which he describes as conglutination and agglutination thrombosis. This latter process presupposes the local heaping-up of platelets which process is one of the two primary factors in thrombus formation the other being stoppage of the blood stream. In my opinion the strength of the hemostatic effect in these larger vessels is determined by the shrinkage and collapse of the vessel wall and not by pressure from thrombus formation in the vessel Based on the idea that satisfactory sealing of these vessels is accomplished by shrinking of the wall Harvey Cushing has originated a novel manner of dealing with them in neurosurgery which is applicable in any region where the vessel is exposed and free from the solid organs. A ball electrode about ⅛ in. in diameter is used in connection with the usual coagulating current of a strength appropriate to the size of the vessel. Beginning at the clamped section of the vessel, its surface is gently stroked in a series of short strokes, which results in pushing the con*tents of the lumen back and sealing the vessel shut as one proceeds*

Conclusions

The effects of high-frequency currents used in surgery depend definitely on the qualities of the current employed Two types of electrosurgical machines are in common use one in which the frequency of oscillation is produced by multiple spark gap and the other by radiotrons or radio tubes The first always produces a somewhat damped current. The less the damping, the more nearly the current produces a clean cut, like an ordinary scalpel wound the more the damping and the higher the amperage the greater the amount of coagulation produced in the tissue at the edges of the incision Both the cutting current and the coagulating current have special indications and advantages in surgical practice. The radio knife can be made to produce a cut without coagulation as the current is not damped. By increasing voltage and amperage in this machine a coagulating cut can be produced but this is likely to be associated with charring and prevents penetration of the coagulation into the tissues.

Experimental cuts were made with both types of current on the skin of the human dog rabbit and frog. The first three of these have a skin with a stratum corneum and in the presence of this layer some coagulation results before penetration of the skin can be accom-

plished even with a pure cutting current This coagulation does not necessarily interfere with primary healing but only 60 per cent of the cuts produced in dog's skin healed by primary intention The skeletal muscles and the muscular layers of the stomach and intestine can be severed with a cutting current without coagulation The phenomenon of vessel closure with a coagulating current is an interesting one involving collapse shrinkage and agglutination of the vessel walls without extensive thrombus formation A large amount of thrombokinase seems to be liberated in cutting capillaries and small vessels There are many serious errors to be avoided in coagulating vessels Too rapid coagulation causes explosion and subsequent hemorrhage

In coagulation of tissues the specific resistance of the tissues varies tremendously e g fat is more than eight times as resistant as muscle making the direction of deep coagulation uncertain

The present tendency in electrosurgery is toward the use of cutting currents and away from massive coagulation as being unsurgical and dangerous

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CHAPTER TWENTY

ELECTROSURGICAL METHODS

WILLIAM L CLARK, M D

The value of electrosurgical methods in general surgery has been established These methods are gradually coming into more general use and are growing in importance to the surgeon. Owing to this fact an exposition of the newer units is herewith presented for the infor mation of physicians not yet familiar with their advantages and disadvantages The present chapter will deal with the more useful elec trosurgical methods upon the basis of the effects produced in the tissues, which will be classified as electrodesiccation electrocoagula tion and the high frequency knife

ELECTRODESICCATION AND ELECTROCOAGULATION

There is an impression among many of the profession that the electrodesiccation and electrocoagulation methods are one and the same. This is an error inasmuch as the effects produced on the tissues are quite different and these can be readily demonstrated both clinically and histologically The type of high frequency current by which electrodesiccation is produced is of relatively high voltage and low amperage whereas the current by which electrocoagulation is produced is of lower voltage and higher amperage. This variability in factors permits the surgeon to utilize the current to best advantage in a wide range of neoplastic lesions

Electrodesiccation.—The electrodesiccation effect produced by the application of one of the forms of high frequency currents to the tissues was first recognized by the writer in 1908 and it was described by him before the American Electrotherapeutic Association in Sara toga Springs N Y in 1910 It was demonstrated that benign or malignant growths of small or moderate size can be destroyed by the utilization of heat of just sufficient intensity to electrodesiccate or dehydrate the tissues The heat for the purpose is produced by a monopolar high frequency current of the Oudin type the current being conducted to the lesion by means of a steel needle or other pointed metallic applicator Either a single or a multiple spark gap may be employed in the circuit but it must be so constructed as to be subject to refined regulation The proper current strength necessary to destroy growths of different types and sizes can be learned best

from actual experience. The electrodesiccation effect may be produced in the tissues either by delivering the current through a short air space to the growth to be treated, by touching the surface with the electrode without an air space intervening, or by inserting a needle electrode more or less deeply, the method of application depending upon the type of case under treatment, whether the affection is superficial or deep, and also upon the degree of tissue destruction desired.

Fig. 1 —Multiple moles of face

Fig. 2 —Illustrating the cosmetic result obtained after removal by the electrodesiccation method. When the operation is well performed there is seldom a resulting contracted or elevated scar

Fig. 3 —Early basal-cell epithelioma of the face.

Fig. 4 —Result of electrodesiccation operation no recurrence after 18 years patient still living, 18 years.

The electrodesiccation method with modification of technic is used advantageously when the lesion is comparatively superficial and localized and when it is desired to avoid a contracted cicatrix. It is subject to such control that if the technic is correct an exceedingly small growth even on the cornea, can be successfully treated without impairment of vision or the subsequent formation of discernible scar tissue. A small growth on the vocal cords may likewise be destroyed without impairment of the voice Likewise such a delicate structure as a hair follicle may be destroyed quite as accurately by electrodesiccation if correctly employed as by the electrolysis needle

The electrodesiccation method has been found to be most satisfactory for the treatment of localized epitheliomas or sarcomas occurring

Fig. 5.—Extensive basal-cell epithelioma temporal region including some bone and outer canthus of eye. This patient had received intensive treatments by both radium and x-ray Temporary healing but recurrence resisted radiation treatment after that.

Fig. 6.—End result of one electrocoagulation operation under ether anesthesia. No recurrence in three years patient died of pneumonia.

upon cutaneous surfaces or accessible mucous membranes If the lesion is extensive and of a very malignant character wide resection after electrodesiccation with the electrosurgical knife is a practice to be recommended Likewise electrodesiccation can be employed advantageously with a good curative and cosmetic effect in the treatment of such benign lesions as warts moles nevus vasculosus and pigmentosus angiomas tattoo marks xanthomas lupus vulgaris and erythematosus chronic varicose ulcers localized infections such as carbuncles certain cases of exostosis as of the hard palate epulis leukoplakia papillomas urethral caruncles cervical erosions endocervicitis hemorrhoids infected tonsils and some other lesions

While in competent hands electrodesiccation has been successfully used in all the above-mentioned lesions it might not be the best policy to employ it in every such case Some of the conditions might even

be aggravated if the method is employed by one not experienced in its use Electrodesiccation is therefore but one other method from which to choose after a correct diagnosis has been made by surgeons conversant with its uses and limitations

Electrocoagulation.—Electrocoagulation is produced by a bipolar high frequency current of the d Arsonval type. The term diathermy is generally employed to identify the d Arsonval current. The definition of diathermy approved by the Council of Physical Therapy of the American Medical Association is as follows A term employed to designate the use of a high frequency current to generate heat within some part of the body The frequency must be greater than the maximum frequency producing neuromuscular response. The oscillations may be a frequency ranging from several hundred thousand to several million cycles per second When such a current is passed through the body at a sufficient voltage and amperage, the resistance offered by the tissues intervening between the electrodes causes heat to be generated in such tissues It was d Arsonval who demonstrated that passage of high frequency electrical currents through living tissues causes neither direct nor indirect contraction of muscles but does cause the tissues to become heated. Nagelschmidt of Berlin, in 1907 apparently was the first to apply this property to human beings for therapeutic purposes, and to give it the name of diathermy—heating through. The rise in temperature depends not only on the amount of energy absorbed but also on the efficiency of the circulation in carrying off the heat and maintaining normal temperature.'

Either a single or a multiple spark gap may be employed for electrocoagulation, but a good multiple spark gap is preferred since the current can be 'stepped up by its use. The current producing electrocoagulation is more penetrating and intense in action than that producing the electrodesiccation effect In accessible locations it is utilized to destroy larger tissue growths it is also useful in cases where there is extensive bone involvement.

There are many variations of technic in the application of the electrocoagulation method to suit the requirements of individual cases. These variations cannot very well be described with sufficient clarity to permit one to practice them without other study They must be learned from practical experience as well as study if one expects to excel in their use. The technic for the uncomplicated case of some of the electrosurgical operations will however be described later on in the chapter These descriptions will guide the beginner, but the information given for reasons stated previously must necessarily be rudimentary

Whether electrodesiccation or that phase of diathermy designated as the electrocoagulation method is employed the aim should be to destroy the growth completely at a single operation In lesions involv

ing cutaneous surfaces the devitalized tissue should as a rule be removed immediately either by excision or curettage which usually can be accomplished without hemorrhage In some instances it is best to permit the electrodesiccated slough to separate naturally without curettage or excision For example it is best not to excise or curette an angioma after electrodesiccating it. The instrument used for excision should if possible, cut through the tissues already electrocoagu

FIG. 7—Very advanced basal-cell epithelioma involving cheek, osseous structures, and parotid gland. Had resisted ray treatment.

FIG. 8—Result of one electrocoagulation treatment under ether anesthesia Note absence of contracted scar without skin grafting remarkable owing to the great extent of the disease no recurrence in 15 years.

FIG. 9—Showing photograph of same patient taken 12 years after treatment

lated and not through the viable tissues beyond it. If necessary, the base may then receive further electrodesiccation or electrocoagulation treatment.

Excision or curettage immediately following electrodesiccation or electrocoagulation is practiced less frequently in lesions within the mouth, or on mucous membranes elsewhere than upon the skin surface, owing to the greater possibility of secondary hemorrhage which is due to the maceration of the tissues by secretions, and also to the liquefaction necrosis caused by bacterial invasion. When excision or curettage following electrocoagulation is not practiced the devitalized

FIG. 10.—Advanced basal-cell epithelioma of the nose.
FIG. 11.—Showing result of one office electrodesiccation operation under local anesthesia.
FIG. 12.—Illustrating artificial nose sculpture method of reconstruction.

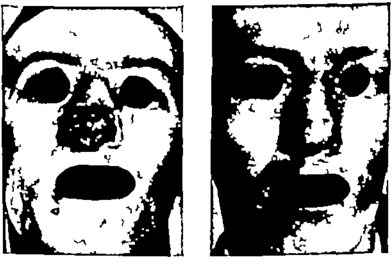

FIG. 13.—Squamous-cell epithelioma of nose, grade 3.
FIG. 14.—Result of one electrodesiccation operation under local anesthesia. Note cosmetic result.

tissue is permitted to slough naturally and to separate by degrees The time which elapses before separation of the slough depends upon the character of the tissue destroyed whether dense loosely combined *friable, or necrotic, and also upon its anatomic location* It may take but two days in some cases for the slough to separate, and in other instances it may take as long as seven days Bone or cartilage when subjected to electrodesiccation or electrocoagulation will sequestrate in from about six weeks to two months depending upon the intensity and quality of the current employed for its devitalization

Fig 15—Basal-cell epitheli ma f the nose
Fig. 6—After one electrodesiccation operation. N te cosmetic result.

Electrosurgical Methods and Irradiation

Since electrosurgical methods radium and x rays are so frequently employed together in the same case one method cannot be properly discussed without also considering the others In dealing with *localized* benign or malignant lesions the superiority of these electrosurgical methods over irradiation is shown by definite histologic changes and by the critical comparison of clinical end results This may be explained by the fact that where electrosurgical methods are employed the diseased tissue only is destroyed and the vitality of the surrounding normal structure is conserved Subsequent treatments by electrosurgery should they be necessary offer quite as good a prospect of success as though the tissues had not received previous treatment owing to this conservation of the vitality of the adjacent tissues On the other hand with irradiation of such intensity as to produce a lethal effect upon the cells of malignant or other types of growths

lated, and not through the viable tissues beyond it. If necessary, the base may then receive further electrodesiccation or electrocoagulation treatment

Excision or curettage immediately following electrodesiccation or electrocoagulation is practiced less frequently in lesions within the mouth, or on mucous membranes elsewhere, than upon the skin surface owing to the greater possibility of secondary hemorrhage which is due to the maceration of the tissues by secretions and also to the liquefaction necrosis caused by bacterial invasion When excision or curettage following electrocoagulation is not practiced the devitalized

FIG. 10.—Advanced basal-cell epithelioma of the nose

FIG. 11 —Showing result of one office electrodesiccation operation under local anesthesia.

FIG. 12.—Illustrating artificial nose sculpture method of reconstruction.

FIG 13 —Squamous-cell epithelioma of nose, grade 3

FIG. 14 —Result of one electrodesiccation operation under local anesthesia. Note cosmetic result.

Indications and Contraindications.—Owing to these resultant changes irradiation should certainly not be used routinely in conjunction with electrodesiccation or electrocoagulation in distinctly localized benign or malignant lesions with the exception of very malignant squamous-cell lesions (such as grades 3 and 4 according to Broders) when irradiation treatment in conjunction with electrosurgical methods should be considered for its lethal effect upon possible outlying malignant cells since there is a greater likelihood of the existence of such cells and of their recurrence in this more malignant type of lesion However after any treatment recurrences may not always be due to incomplete primary work but rather to entirely new lesions occurring in soil favorable to their development

There are instances of advanced cases of malignancy in inaccessible locations in which electrodesiccation or electrocoagulation is not applicable owing to the involvement of vital structures and to the impossibility of doing complete work. *Unless the lesion can be completely removed well beyond into the normal tissue electrosurgical methods are as a rule contraindicated* In exceptional cases a large necrotic mass of malignant tissue may be removed by electrosurgery even though the work is known to be incomplete to permit of the more satisfactory immediate use of radium or x-rays In such cases irradiation, as the most important factor in treatment, is preferable to other alternatives My experience has been such however that I feel strongly that electrosurgical methods with the exceptions noted should be employed alone in primary localized lesions where it is possible to remove all the disease at one operation

Electrodesiccation and electrocoagulation are both contraindicated with the exception noted in extensive lesions that cannot be destroyed in their entirety with one operation If any of the disease is left, it will usually be stimulated to greater activity unless irradiation is immediately employed thereafter If vital structures are involved and the case is inoperable, then irradiation treatment is preferred to electrosurgical or other methods

In addition to removal by electrosurgical methods of primary lesions of the very malignant squamous-cell or other types of growths it is quite important, indeed it is necessary to treat the lymphatic drainage areas by radium or x rays or in some instances by a combination of both, to inhibit or destroy malignant cells migrating to the glands or to destroy the pathologic element if true metastasis has already taken place. In some instances it is necessary to excise the involved glands by means of either the high frequency knife or the cold scalpel This is especially true if the glands have broken down Preoperative irradiation of the metastatic glands inhibits the proliferation of malignant cells thus recurrence after removal is less to be feared Postoperative irradiation at the site of the excised glands is also a practice to be recommended

it is impossible to avoid lowering the vitality of the surrounding normal tissue by producing nerve tissue and circulatory changes. This is true at least to a certain degree Therefore in case of recurrence little more can be hoped from further irradiation treatment owing to the decreased radio sensitivity of the tissues and also to the resultant changes before mentioned These are facts well known to experienced radiologists and other close observers.

Fig. 17—Squamous-cell epithelioma, grade 2 of cheek and angle of lips, extending through into the mouth

Fig. 18—Result of one electrocoagulation operation under ether anesthesia. Radium treatment to lymphatic drainage areas. No recurrence in six years. A plastic operation to close opening into mouth could be successfully performed.

Fig. 19.—Squamous-cell epithelioma f the lower lip, grade 3

Fig. 20—Result of one ffice electrodesiccation operation and radium treatment to neck. Note absr of contracted scar and regeneration of normal tissue.

As before stated electrodesiccation and electrocoagulation are adapted to the treatment of benign and malignant growths of the skin and accessible mucous membranes that are limited in extent and do not involve vital structures These methods are therefore peculiarly adapted to the treatment of neoplasms involving cutaneous surfaces as well as lesions occurring in accessible mucous membranes such as are found in any part of the oral cavity and adjacent parts on the lip jaw nose throat tongue, larynx eye sinuses orbit, par

Fig 25—Extensive basal-cell epithelioma involving whole of upper lip, antrum, nose, septum, alveolus, and hard palate Recurrence after excision radium, x ray and serum treatment.

Fig. 26—Result of one electrocoagulation operation. No recurrence in 15 years.

Fig. 27—Features constructed by sculpture method and attached to spectacle frames.

otid gland ear etc Likewise they may be employed advantageously in growths of the bladder the operator working through an operating cystoscope or through a suprapubic opening also growths of the vagina, urethra, uterine cervix and the rectum may be treated by this method Recent experience has shown that the high-frequency knife may be effectively employed for the removal of growths of the abdominal serous membranes

Since malignant lesions of mucous membranes are prone to be more active than those occurring on the skin the efficiency of electrodesiccation and electrocoagulation is in some instances increased by the combination of the high frequency knife the cold scalpel radium and x rays The basal-cell type of epithelioma, occurring for example

Fig. 21.—Squamous-cell epithelioma of lip.

Fig. 22.—Result of one electrodesiccation operation.

Fig. 23.—Squamous-cell epithelioma, grade 4, completely involving the lower lip and alveolus.

Fig. 24.—Result of one electrodesiccation operation and radium treatment to neck.

The choice between local or general anesthesia in a given case is a matter of the personal judgment of the operator although it might be stated that much of this work can be done under local anesthesia It seems advisable that ether be removed from the room during electrosurgical operations the operation being performed while the patient is coming out of ether Dr Mock states that he covers the ether mask with a wet flannel blanket during electrosurgical thyroid operations He further adds 'Ethylene should never be used when electrosurgery is employed

Fig. 29.—Squamous-cell epithelioma of floor of mouth and alveolus, grade 4.

Fig. 30—Result of one electrodesiccation operation and radium to lymph nodes. No recurrence in 8 years.

Effects of Electrodesiccation and Electrocoagulation.—In addition to the electrodesiccation or electrocoagulation effect on the affected tissues and to the sealing of blood and lymph channels the heat penetrates beyond the area actually destroyed and devitalizes malignant cells for a considerable distance beyond without permanently impairing the normal tissues thus lessening the likelihood of local recurrence or metastasis and conserving the maximum amount of normal tissue It is however difficult or impossible to determine by any means now at our command exactly how far this heat penetrates in a given case and the depth to which the malignant cells are destroyed

Malignant cells especially those that are least differentiated, are more vulnerable to heat and are devitalized at a lower degree of heat

on cutaneous surfaces, such as the face and eyelids is of relatively low grade malignancy, and though the lesions may be extensive both as to area and depth even though complicated with bone involvement, they may be so effectively treated by the electrodesiccation or electrocoagulation methods that recurrences are infrequent provided the operations are properly performed

In localized squamous-cell epitheliomas however on cutaneous surfaces or mucous membranes which are found to be more malignant in type, the results are almost but yet not quite as good as in the basal cell lesions, the results depending to a great extent upon the grade,

FIG. 18.—Illustrating the result of an electrocoagulation operation for removal of a very far advanced rodent ulcer involving the whole of the upper lip, nose, maxillary ethmoids, frontal sinuses and left orbit The dura was exposed, yet the patient recovered and lived for three years after the operation.

or in other words upon the degree of differentiation in the cells from the embryonic to the adult cell. This differentiation can be demonstrated by the trained pathologist The recognition of differentiation in cells has proved a valuable guide in planning treatment. In such cases radium or x-rays should be used locally in combination with electrodesiccation and electrocoagulation When the cells are embryonic in character they exhibit but slight resistance to irradiation treatment. On the other hand when differentiation has progressed they show greater resistance Therefore to obtain good results the dosage must be increased to overcome this resistance. When the growth is no longer localized and metastasis has occurred it is again emphasized that other methods must also be used in addition to electrosurgical methods.

ated cells is also well established This property of heat penetration should not however influence the operator to do incomplete work for it cannot be relied upon entirely in all instances to destroy deeply located malignant cells. It is safer to err on the safe side by performing radical operations when one has to deal with malignancy The sealing of blood and lymph channels and the prevention of dissemination of malignant cells should be an advantage and might conceivably aid in preventing local recurrence and metastasis The frequent immediate relief from pain after operation is worthy of note There is no field of surgical specialization in which electrosurgical methods cannot be employed to advantage in some cases

Fig. 34 —Illustrating a case of epulis. Electrodesiccation is a successful method of treatment, conserving the maximum of normal structure

Apparatus and Operator —High frequency apparatus as devised by different manufacturers vary greatly in construction hence there is a corresponding variation in the quality of the currents produced The thermic intensity may be too great or too little and an undesirable faradic effect producing shock and contraction of the tissues is to be expected when the improperly constructed machines are used This lack of standardization is unfortunate since in order to produce the electrodesiccation and electrocoagulation effects under ideal conditions an accurate balance must be obtained between the voltage and the amperage and also between the capacity inductance and resistance. Thus different operators employing various types of apparatus may obtain different results Indifferent results can be obtained or indeed irreparable damage can be done by an operator not possessing practical knowledge of the various factors involved This notation seems appropriate and most important since a considerable number of cases have come under observation that have been improperly treated by electrodesiccation and electrocoagulation thus an errone-

than are normal cells This seems to have been demonstrated by the experimental work of Doyen and others and it has been borne out by my own practical experience The thermic sensitiveness of these cells to the action of the high frequency current has often been observed clinically and demonstrated histologically Likewise, the greater sensitivity to radium and x rays of embryonic cells than of well-differenti-

FIG. 31 —Showing typical result of one electrocoagulation operation for extensive squamous-cell carcinoma of antrum hard palate and alveolus.

FIG 32 —Showing properly fitting denture to fill up space insuring improved speech, mastication and greater cleanliness.

FIG. 33 —Illustrating a case in which an electrocoagulation operation was performed to remove extensive carcinoma of the antrum after surgical exposure through an external opening The hard palate and alveolus were not involved with disease.

ous impression has been made on the minds of those seeking authentic knowledge concerning the methods Moreover electrosurgical methods can be practiced with a maximum degree of satisfaction only by those who have had ample surgical training and experience These methods should not be considered as something distinct and apart, or as a specialization but rather as a valuable adjunct to the surgeon trained in surgical judgment and technic, and with sufficient operative experience.

General Technical Considerations —There are many variations in the technic of electrodesiccation and electrocoagulation to meet various indications The technic cannot be completely described it

Fig. 19.—Showing a case of adamantinoma, associated, as is usual, with bone cysts. Electrocoagulation is a successful method of treatment

must be learned by studying the technic of a capable operator and then further perfected by practice upon raw meat and laboratory animals before human subjects are treated I desire to impress the fact that the technic of electrodesiccation and electrocoagulation is not simple nor should the work be undertaken lightly Much good can be done by using them judiciously and perhaps considerable damage can result from their improper use even in the hands of otherwise accomplished surgeons. Thorough preparation should therefore be made before engaging in what might possibly be a hazardous procedure While those who employ electrosurgical methods judiciously have reason to be enthusiastic they should not grow so enthusiastic as not to realize the limitations of these methods for they do have limitations The cold scalpel hemostats and sutures cannot by any means be discarded from use in general surgery


Fig. 35—Showing result of a radical electrocoagulation operation for extensive carcinoma involving alveolus hard palate and antrum on both sides.

Fig. 36—Showing deformity in natural position after operation.


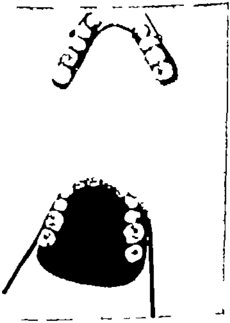

Fig. 37—Natural appearance after the use of a properly fitting denture.

Fig. 38—Showing upper and lower dental plates used in this case.

Each case should be regarded as a law unto itself and after full advantage has been taken of our superior present-day laboratory and other facilities should be studied intelligently and judicially before a decision regarding the proper method, or combination of methods is reached in a given case

Group Practice.—Since it is well-nigh impossible for one man to become thoroughly proficient in the expert application of all measures hitherto mentioned group practice is perhaps the best solution of the difficulty If one is not in a position to employ all recognized methods and adjuncts either by oneself or in group practice, one should not attempt to treat cancer except, perhaps in selected cases

FIG. 43.—Leukoplakia of the tongue. Electrodesiccation is the most satisf ctory treatment f r this lesion on any accessible mucous membrane

Hemorrhage.—When electrodesiccation or electrocoagulation is correctly employed hemorrhage during or immediately after the operation is not likely to occur Secondary hemorrhage may possibly occur several days later at the time of separation of the slough when the larger vessels have been electrodesiccated or electrocoagulated through. Usually however organization has taken place by the time the slough separates and the terminal ends of the vessels have thrombosed thus preventing hemorrhage. This however cannot always be depended upon This risk when such a possibility appears to exist, should be obviated by preliminary ligation of the involved blood vessels if it is practical to do so in a given case This is especially true when the electrodesiccation or electrocoagulation method is employed in which case sutures are not used and the wounds must heal by granulation. When the high frequency knife is employed the larger

Operators should therefore be trained to know when other methods are indicated in *preference to electrosurgical methods, and also when* other methods should be used in conjunction with them Contrariwise they should not employ cold scalpel surgery when electrosurgical methods can be employed to better advantage We should not lose sight of the respective value of the cold scalpel the high frequency knife, radium, and x rays especially in cancer work, each having a place in modern practice Electrosurgical methods cannot be practiced to full advantage without according to the other methods full and equal consideration Electrosurgery is but one, though a valuable unit in the progressive surgeon's armamentarium.

FIG. 40.—Extensive squamous-cell epithelioma of tongue and floor of mouth grade 2

FIG. 41.—Appearance after amputation *of tongue* by the electrocoagulation method and radium treatment to lymphatic drainage areas in neck.

FIG. 42.—Showing artificial tongue made of cotton, thus materially improving speech

of the high frequency knife Some surgeons of experience who have weighed both methods in the balance prefer the latter method

May I stress the important fact that the use of the electrodesiccation or electrocoagulation method of treatment will frequently reclaim cancer cases that would have been quite hopeless were these methods not available.

Histologic Studies.—The microscopic picture of neoplastic tissue submitted to electrodesiccation presents typical characteristics While the cells still retain their outline they appear shrunken elongated and dried up Evidence of such degenerative changes as hydropic or fatty degeneration is not discernible The blood vessels in the immediate and adjacent field of operation are thrombosed

Fig. 45—Illustrating a case f advanced squamous-cell carcinoma, extending through the cheek, also involving the alveolus, floor f mouth and tongue, with metastasis to the cervical glands. Much f the cheek and diseased parts in other locations removed by electrocoagulation, lower jaw resected, and radium used interstitially in the glands. After a year without recurrence, plastic operation was performed, utilizing a flap from the chest. No recurrence in 5 years.

In tissue subject to coagulation there is complete loss of cell outline The neoplastic cell element seems to have fused into a structureless homogeneous mass with a resulting hyalinized appearance. The blood and lymph channels are thrombosed The secondary and associated changes in all such lesions are degeneration and fibrosis. Whether the fibrous and connective tissue shall be abundant and dense or less abundant and soft is influenced by the amount and nature of the accompanying degenerative and necrotic material which in turn are determined by the particular type of irritant. Thus after electrodesiccation the fibrosis is slight and the resulting scar is soft and pliable Following electrocoagulation the fibrosis will be more or less abundant, the amount depending on the intensity of the heat generated and the consequent degree of frame destruction

vessels should always be ligated and the incision closed by proper suturing, the wounds are then expected to heal by first intention. Disappointment in this has however, sometimes occurred, depending for the most part upon the dexterity and the experience of the operator in the use of a new method and instruments.

Gastrostomy and Colostomy—In cases of mouth and throat malignancy when a patient s vitality is low and he is undernourished owing to his inability to ingest the proper amount and quality of food

FIG. 44.—Illustration of exostosis of hard palate which sometimes should be removed to make possible a properly fitting denture and for other reasons. Electrodesiccation is ideal for the removal of this lesion and the danger of breaking through into the antrum is minimized.

and when tube feeding through the nasal passage is impractical a preliminary gastrostomy should be performed and the patient fed through a tube until in proper physical condition to withstand the proposed operation. It is noteworthy how some patients improve physically after resorting to the rational expediency of gastrostomy A gastrostomy can readily be done under local anesthesia, and the opening in the stomach can be closed after it has served its useful purpose. It is likewise prudent in the majority of instances to perform a colostomy before attempting treatment of cancer of the rectum.

There are numerous other circumstances frequently met wherein the combination of the cold scalpel and some form of electrosurgery can be employed to advantage. Such operations as gastrostomy and colostomy may be performed either by the cold scalpel or by means

shorter operations the decrease in trauma, and the greater possibility of sterilization are the chief advantages of the method

At a conference on electrosurgery during the meeting of the American College of Physicians in Philadelphia, October 1930 Dr Howard A. Kelly spoke upon the subject of electrosurgery in part as follows

In brief summary some of the conditions with which we deal are
Various malignancies about face, lips mouth tongue fauces.
For carbuncles it renders signal services in exsecting the diseased area leaving a clean sound, aseptic, rapidly healing wound in fact it undoubtedly

FIG. 47—Squamous-cell carcinoma of parotid gland ear and lower jaw with infiltration into neck.

FIG. 48—Result f combined electrocoagulation radium treatment and resection of lower jaw Patient is living without recurrence after 10 years, though with facial paralysis.

FIG. 49—Squamous-cell epithelioma involving the parotid gland and other tissues.

FIG. 50—Showing result f one office electrodesiccation operation under local anesthesia. Facial nerve not injured no recurrence in 6 years patient still living.

Conclusions Regarding Electrodesiccation, Electrocoagulation, and Combined Methods.—Electrodesiccation and electrocoagulation when employed with correct technic are perhaps the most satisfactory methods yet designed for the treatment of localized neoplastic and allied lesions of the skin and mucous membranes The cold scalpel the high frequency knife, radium and x ray are also valuable and indispensable in their respective rôles and in some instances they may be used advantageously in combination with electrodesiccation and electrocoagulation, each method complementing the other

FIG. 46.—Illustrating line of excision to expose malignant disease of the upper jaw anterior nares antrum, floor of orbit and buccal surface preliminary to treatment by electrocoagulation.

HIGH FREQUENCY KNIFE

Owing to the flexibility of the high frequency currents it is possible so to regulate the capacity inductance and resistance with variable degrees of damping as to permit cutting through the tissues with a suitable electrode quite as accurately and as cleanly as by the cold bistoury, moreover the wounds will heal by first intention I had the opportunity of experimenting with and reporting to the manufacturers upon, one of the first practical machines and instruments designed for this work about one year before it was adopted for practical use Dr George A. Wyeth, of New York City following up these studies first called the attention of the medical profession to the perfected cutting current in a paper read before the Surgical Section of the New York State Medical Society in Rochester N Y April 1924 Schmidt Kelly Ward Cushing Mock Trowbridge and others later contributed toward the development of this method Surgeons throughout the world are now widely employing it in major surgery including abdominal intestinal thyroid, gynecologic, genito-urinary nose and throat eye ear and brain surgery especially in the case of neopla i diseases The minimized primary hemorrhage the

sulating tissues by coagulation In the spinal cord it is easy to prognosticate a use in all lesions where it is simply necessary to divide a nerve trunk or to destroy benign or malignant growths *in situ* without the usual protracted manipulations for exposure and removal with the attendant traumatisms

In all these operations it is advisable to maintain the careful technic of the operating room in major and minor surgery This should be done for our own sakes and in no wise to impress the patient. How far we may safely modify our stringent technic will appear only after considerable experience.

In closing I feel profoundly thankful that our honorable society composed as it is of our leading surgeons, is seriously taking this matter in hand. Personally I give thanks for such a new and potent adjuvant which simplifies our technic, speeds the operation does many things better and some things heretofore impossible while it greatly lessens pain and the liability to subsequent infections [*Surg Gynec Obst* p 503 (Feb 15) 1931]

Dr Oscar E Nadeau Chicago Ill summarizes his experience as follows "The electrosurgical unit in its present state of development is a distinct advantage in modern surgical technic. New indications are found every day It is a new method the details of which must be thoroughly familiar not only to the surgeon but to the entire staff of assistants and nurses [*Surg Gynec Obst* p 511 (Feb) 1931]

Dr Howard Lillienthal of New York City at the conference mentioned drew from his experience the following conclusions

1 The electric method under discussion promises to be a great aid in general surgery

2 The tendency to wound infection is greatly reduced.

3. Hemostasis is quick and sure. In my small series of cases there has been no secondary bleeding

4. Healing has been normal in rate and in firmness The time is too short to form conclusions as to keloid. Thus far I have not observed this condition

5 When local anesthetics were employed my impression is that there may have been electric subjective reactions of pain and that the pain or discomfort was more than when the scalpel was used On dividing muscle there has been more twitching than is ordinarily seen on knife section (Twitching is caused by faradism due to improper windings in apparatus — W L. CLARK.)

6 The apparatus must be properly managed Its liability to get out of order or to diminution in functioning power may have to be considered. Thus far I have not noted deterioration of this kind It seems to me that the electric method is extremely valuable in general surgery and that the wounds are more likely to be aseptic than those in which the scalpel is used.

In this discussion I have not dealt with the technical part of electrosurgery There is danger of producing accidental burns by contact of the electrode with metallic bodies in the wound such as metal retractors or artery clamps. I believe that the principal use of the new method in general surgery will be for making incisions in the soft parts, including the skin and of course, in the removal of lesions outside the body cavity The action of the electrode on the tissues seems to be that of intense heat, but the intensity is so great that with the cutting motion there is rapid

replaces the actual cautery which has been growing in favor, and is infinitely superior to the wretched poulticings

No method outside of the wonderfully effective services of radium is worth considering in dealing with malignant tumors of the scalp

In malignancy of the skin in all parts of the body electrosurgery is second only to radium It supersedes radium in nevi Often when the use either of the x ray or radium has been overdone and there still remains a sclerosed or an extensively ulcerated mass nothing approaches the efficiency of the exsec tions of electrosurgery

Epitheliomas of the dorsum of hand or wrist even when the growths ex tend into the tendons, are admirably handled by electrosurgery which is secondary only to radium well managed.

For certain breast cases it is supreme, especially in the presence of nodular ulcerated, massive scirrhous breasts, when there is not a shadow of a hope of a successful removal by classic methods. In such case electrosurgical extir pation of the mass often proves of inestimable value in stopping the pain and the discharges, as well as in freeing the poor victim of the unsightly reminder of a doom daily approaching Nor need one always hesitate even when there is fixation of one or more massive glands. After the main mass is removed areas of lingering disease can often be coagulated out of exist ence and glands can be removed, or with the fire of the heavy flashing current, destroyed *in situ* and left to be absorbed Some patients in this group express more gratitude for relief than others do for a radical cure. In many instances recurrences are slow to occur and when the patient is old it becomes a special blessing as she may go to the end apparently cured.

Malignancies about the abdomen offer a fertile field for electrosurgery We can destroy papillomatous ovarian implants faster than it can be stated. Small areas of carcinoma are readily destroyed and left where found while a scirrhous nodule in the intestinal tract can be widely destroyed even through into the lumen of the bowel, and abandoned after turning it in and suturing the wound with a couple of Lembert sutures. In resecting the bowel for malignancy if one finds an affected gland in the fork of a large mesen teric vessel distant from the field of operation it can be wiped out of existence by puncturing it and coagulating the whole gland if needs be, by grasping the vessels with the fingers to limit the transmission of the heat.

Malignant vulvar disease should always be removed by electrosurgery and any inguinal glands sparked out of existence.

In experiments on the liver and kidney, Ward and Pearse have resected portions of both organs with a marked lessening of the hemorrhage. In the liver there was practically no bleeding during excision of a complete lobe. In nephrotomy and partial nephrectomy, in spite of the large arterial supply of the kidney bleeding was markedly diminished in the peripheral areas. In the neighborhood of the pelvis, the larger vessels required clamping and coagulation. Scott has carried this into the clinical field removing portions of the kidney for tumors and stone.

Electrosurgery is opening up a large field in brain work as it will in spinal cord surgery In the brain, as shown by Cushing electrosurgery is of the greatest value in opening up the meninges, in making a safe passage to an abscess, and above all in the effective handling of hemorrhage. It also enlarges the field of control over malignancy simplifying the removal of the disease in sterilized "curls" and in the further treatment of the encap-

tends perhaps, to prolong solid union. This is of course not necessarily the fault of the electric technic, for slow healing in fat subjects is never surprising Broad approximation of wound surfaces and an interval of a day or two longer before removing sutures are advised

The electric scalpel cuts so keenly and with so little pressure on the tissues that great care must be taken not to go deeper than is intended For example, in dividing the abdominal wall the peritoneum should be entered in the usual way with knife or scissors for fear of injuring the viscera by the current. In the region of large vessels or of important nerves, the greatest delicacy of manipulation must be observed.

FIG. 53.—Large round-cell sarcoma involving face antrum, malar bone, floor of orbit, and ethmoid sinuses, as well as tissues within the orbit.

FIG. 54.—Showing result of one radical electrocoagulation operation including exenteration of orbit. (No other method could possibly have produced such a result.)

The outstanding features of electrosurgery are the saving of time the greater assurance of asepsis and the reduction of what may be called the massage effect, so dangerous in operating through infected or neoplastic structures. [*Surg Gynec Obst* p 513 (Feb) 1931]

Dr Edward L Keyes of New York City spoke conservatively though in the main favorably of electrosurgical methods for certain operations in the genito-urinary field.

Dr John D Ellis of Chicago in his paper The Healing of Electrosurgical Knife Wounds summarizes as follows

1 Only 60 per cent of electrocutting skin wounds in dogs where the minimum of current was used healed by primary intention as compared to 97 5 per cent of scalpel wounds

2 This 60 per cent which healed did not present a tensile strength equal to the scalpel wounds for 21 days

linear disintegration of tissue with minimum charring or coagulation A cautery blade of the ordinary type loses its heat by contact with the tissues, so that coagulation is more massive and the knife sticks to the surface of the wound With the electric scalpel on the contrary the wound is clean cut and except for the absence of bleeding its edges in skin incisions resemble those made with the sharp knife.

Skin fat and muscle are divided without apparent effort by the operator and denser structures such as fibrous tissue may also be sectioned but more slowly Capillary oozing is practically absent. With the rapid current which I have used in my operations, there is bleeding from many

FIG. 51—Extensive basal-cell epithelioma of the rodent ulcer type involving the abdomen two ribs, and at one point extending almost through to the peritoneum.

FIG 52—Result of one electrocoagulation operation under ether anesthesia No recurrence in 6 years. No other method but electrocoagulation could have accomplished such a good result.

of the smaller as well as the larger vessels when they are divided but this depends of course on other things than the mere division of the vessel, e. g the coagulability of the blood and the elasticity of the vascular walls, as well as the hydrostatic pressure in their lumen. All bleeding points are caught with forceps Whether a vessel needs to be ligated or whether it may be permanently sealed by touching the clamp with the coagulating electrode can be determined only by experience. As a rule, however a small spurting vessel which has been sealed should not bleed on lightly sponging the wound. If there is any doubt, ligation should be done as in ordinary surgical procedure. In any event, I believe it is safest to deal individually with wounds of the vessels. Secondary hemorrhage in the absence of suppuration is no more likely to occur after an electrically made wound than after an incised one. I confess to insufficient experience to generalize too certainly in this matter although in some of my cases the wounds have been very extensive. *When there has been neat approximation primary union may be confidently expected* I feel however that in the electrically produced wound the presence of a thick adipose layer

1 Rapid and complete severance of the tissues whether for removal or simple incision through normal or abnormal structures The rate of speed in handling the electrode together with the power control governs the degree of dehydration and the electrocoagulation of the severed surfaces and hence controls or checks the bleeding or oozing from capillaries and also seals the lymph vessels thus giving a clear operative field Such a clear operative field favors an easier and quicker operative technic, together with the elimination of the obstructive hemostatic forceps and the constant and bothersome use of gauze sponging, thus reducing the time limit of an operation—major or minor—to a minimum While the smaller blood vessels are thus controlled by the dehydration of the cutting electrode the larger vessels should invariably be ligated as a procedure of safety

FIG. 57—Basal-cell epithelioma involving upper and lower eyelids, canthus, and conjunctiva.

FIG. 58—Showing a typical result of the electrodesiccation removal of such lesions. I have personally treated over 500 cases of epithelioma of the eyelids and canthi, and my experience indicates the great value of the electrodesiccation method in these lesions.

2 The facility of using the electrosurgical knife is acquired only by *thorough* study of the manipulation and *strict* attention to the principles governing the use of the same upon living tissues of the human body after multifold experimentation upon a nonviable subject.

In so using the electrosurgical knife it has been the custom of the writer to entrust the management of the foot switch—which lets on or releases the current—to the trained assistant operating nurse who at the announcement of "on" or "off" controls the current. This feature cannot be emphasized too strongly inasmuch as the operator should give his sole attention to the technic of the operation and not be disconcerted by the use of either foot on the switch then too the operator can then be free to change his position as the exigencies of the operation demand

A novice should never be allowed to use the electrosurgical knife on the living human body nor should any surgeon attempt to use it without previous close study of its applicability and manipulation

3 Incisions of the stomach and muscle with the electric knife present *a much more satisfactory percentage of union and strength of cicatrization* comparable to the wounds with the scalpel, except that the electrocutting wounds of the stomach were notably weaker at the midpoint of healing.

Dr A C Scott, Temple Texas in his paper, 'Electrosurgery in the Treatment of Malignant Disease stated "Observation in the use of the loop cautery knife in more than 1,500 operations for malignancy leaves us with no other alternative than the conclusion that at present it is the safest and most dependable means of eliminating local recurrence of malignancy after major surgical removal"

FIG. 55.—Extensive basal-cell epithelioma involving the eye all tissues in the orbit, bone, nose and tissues surrounding the orbit.

FIG. 56—Result of removal of diseased tissue including complete exenteration of orbit by the coagulation method.

Other papers by Dr H F Pierce Ph. D, Baltimore Md Dr A. L MacLean, Baltimore Md and Dr Bowman C Crowell Chicago Ill., commented favorably upon the possibilities of the high frequency knife in general surgery

The following has been contributed by Dr Edward H Trowbridge A.M M.D F.A.C.S of Worcester Mass

In the employment of any special instrument or apparatus in surgery certain prerequisites are obvious.

A. General applicability

During the past three years the electrosurgical knife has been used in all operative cases in the Harvard Private Hospital, Worcester Mass., whether major or minor in character such as incisions through the abdominal wall, cholecystectomy appendectomy cystotomy abdominal hysterectomy (supravaginal and complete) cesarean section amputation of cervix

B The various features of the electrosurgical knife are as follows

ceps, which would obscure the field and retard the progress of the operation was eliminated and a more rapid operation performed, as time was an important element. The writer is an ardent advocate of the electrosurgical knife.

Neoplasms of Face, Nose, Eyelids, Ears and Cutaneous Surfaces Generally

Neoplasms of the face, nose, eyelids, ears, etc., whether benign or malignant, require a method which will insure a good cosmetic result without sacrificing thoroughness of removal. Unless the lesion is very

Fig. 61.—Melanotic sarcoma involving the orbit, ethmoidal and frontal sinuses.
Fig. 62.—Result of one electrocoagulation operation.
Fig. 63.—Showing artificial eye and brow by the sculpture method.

Fig. 64.—Mixed-cell sarcoma originating in the ethmoid sinus, filling the orbit, and causing great bulging of the eyeball.
Fig. 65.—Result of radical coagulation operation and radium treatment. Photograph taken four years after the operation.

The advantages in the use of such an electrosurgical knife are readily comprehended as when employed in the removal of the gallbladder, and likewise in pelvic surgery where the structures to be removed are so deeply situated and at times, so difficult to manipulate.

3 The healing of the tissues

Primary healing is invariably obtained, and the ideal line of union is the pleasing result. This result, however, may not be achieved if the tissues be subjected to a too extensive dehydration of the cut surfaces and a slight or somewhat enlarged slough be caused and healing be thus retarded. Such a condition did occur in the experience of the writer in doing a cystotomy for the removal of two large calculi on a person with thick abdominal wall. This case was among those first operated upon with the use of the knife, but no such experience has occurred since that time.

FIG. 59.—Showing a recurrence after surgical excision of a small round-cell sarcoma of the lower eyelid

FIG. 60.—Again illustrating the result of one electrodesiccation operation without cicatricial contracture and regeneration of normal tissue. Patient can close eyelids, and vision is not impaired This case was followed for eight years and no recurrence was observed.

4. After results. Very little or no opiate at all is required postoperatively Drainage in less amount—drainage tube removed within shorter interval (two to four days)

Case of complete hysterectomy on January 2 1932 age 70 operation refused for over two years relief demanded by patient. The electrosurgical knife used in opening the abdomen and in severing the broad and round ligaments and in severing the cervix from the vaginal junction, a boggy uterus size of grapefruit exposed with two fibroids size of English walnut on either side of uterus just above cervix. The uterus was so rotten at the cervical junction that the tissues were easily torn when traction was made, and hence the necessity of removing the uterus as in supravaginal technic and then the cervix subsequently

In all this procedure the minimum amount of blood was lost such a favorable resul however could not have been possible had the ordinary scalpel been used Then, too the necessity of using several hemostatic for

ceps, which would obscure the field and retard the progress of the operation, was eliminated, and a more rapid operation performed, as time was an important element. The writer is an ardent advocate of the electrosurgical knife.

Neoplasms of Face Nose Eyelids Ears and Cutaneous Surfaces Generally

Neoplasms of the face nose eyelids ears etc whether benign or malignant require a method which will insure a good cosmetic result, without sacrificing thoroughness of removal Unless the lesion is very

Fig. 61 —Melanotic sarcoma involving the orbit, ethmoidal and frontal sinuses.
Fig. 62 —Result of one electrocoagulation operation
Fig. 63 —Showing artificial eye and brow by the sculpture method.

Fig. 64.—Mixed-cell sarcoma originating in the ethmoid sinus, filling the orbit, and causing great bulging of the eyeball.

Fig. 65 —Result of a radical coagulation operation and radium treatment. Photograph taken four years after the operation.

extensive, the electrodesiccation method admirably fulfils these requirements Given a case of epithelioma of moderate size on the face or other locations mentioned, requiring complete removal, the technic of an electrodesiccation operation is briefly described as follows

Technic.—The patient should lie in a convenient position on an operating table Preliminary cleansing and sterilization of the operative field is first practiced as in any surgical operation Novocaine (1 per cent) anesthesia by infiltration well beyond the lesion has been found

FIG. 66 —Congenital cavernous angioma of the orbit.

FIG. 67.—Showing complete exenteration of the orbit by coagulation. Eyelid was divided and dissected back so as not to be injured by the current.

FIG. 68 —Lids after suturing before patient came out of ether

FIG. 69 —Ultimate result with conservation of eyelids. An artificial eye is under consideration.

to be quite satisfactory After the current is regulated to the proper intensity as hitherto described it is passed through a sharp sewing needle held in a suitable handle of which there are several types available for the purpose on the market Owing to the relatively high voltage of the current producing the electrodesiccation it is not necessary to employ an indifferent electrode anywhere on the patient s body to complete the circuit. The current is carried to the ground thus sufficiently completing the circuit through the patient s body

The growth is then electrodesiccated through its area and depth (according to the general technic described under the heading

FIG. 70.—Glioma f the retina. Recurrence after regular surgical removal. In five weeks it had recurred and progressed so rapidly that the growth measured 25 inches in circumference.

FIG. 7 —The outside lesion as well as the disease in the orbit was removed by the electrocoagulation method. N recurrence in 9 months, when the child died of another disease the character of which was not determined.

ELECTRODESICCATION) after first systematically cutting off the blood supply with the current in the normal tissues well beyond the disease if it be malignant. This preliminary practice is designated by Kelly as circumvallation." After the lesion has been thoroughly devitalized it may be curetted away if soft and friable or excised by scissors cold scalpel or the high *frequency knife if dense and firm* The cutting however should be done through the electrodesiccated tissue if pos sible and not beyond it into the healthy tissue There should be no primary hemorrhage and indeed no secondary hemorrhage unless a fairly large vessel has been electrodesiccated through Precautions should be observed to obviate this possibility as hitherto described. The wound is dressed according to classical surgical rules the remain

ing slough is removed when separation takes place, and healing may be expected to progress rapidly The curative and cosmetic results in a great variety of neoplastic lesions on the face and adjacent parts are superior to other methods designed for the purpose

Neoplasms of Lips, Oral Cavity, Jaws, Orbit, and Sinuses

Electrodesiccation and electrocoagulation are adapted for minor operations and also for the radical removal of benign and malignant growths in these locations The advantages of these methods accord

Fig. 71.—Showing a case of squamous-cell carcinoma of the vocal cords, treated by electrodesiccation by direct vision through a laryngotomy opening. Radium treatment was also given from the outside No recurrence in 10 years. A similar result was obtained in two other such cases.

ing to my experience are the comparative freedom from hemorrhage in otherwise sanguinary operations the conservation of the maximum amount of tissue the ease of devitalization and removal of bone even when the involvement is extensive the immediate relief from pain (which in these cases is often excessive) the absence of contracted scars and the conservation of vitality in adjacent normal tissues. In case of recurrence another operation can be performed with as good a chance of success as before the first operation This is not true of radium or x ray treatment for once treatment to saturation is accomplished nothing more can be expected from their use at any future time. Even after radium or x rays have been employed to the limit without success or after recurrence following their use electrodesiccation or electrocoagulation may still be used with a fair chance of success With increased personal experience with all surgical and irradiation method. I am impressed with the inferiority of the older surgical methods for the removal of neoplasms in the locations under

discussion and the superiority of the electrosurgical methods in these locations. I am also led to the firm conclusion that radium should not be employed in intensive doses near bone, since radium necrosis of the bone is almost certain to occur sooner or later and that condition is almost as serious to the patient as the malignant lesion for which *it was employed For example in the light of present knowledge it is a* most reprehensible practice to apply radium in the maxillary sinuses. It may be employed from the outside however with comparative

FIG. 73—Mixed-cell sarcoma of bulbar conjunctiva and cornea.

FIG. 74—Result of one electrodesiccation treatment, with no perceptible scar and no impairment of vision This case illustrates the practicability of treating growths near the cornea. Many such lesions have been successfully treated.

safety since the advantage of distance is obtained and filtration of softer destructive rays is then possible Radium or x ray treatment to the lymphatic drainage areas is a different matter and the use of one or the other should be the routine practice I am strong in the belief that all primary lesions in the locations mentioned should be removed by one or the other of the electrosurgical methods, for reasons that are so valid that possible arguments against such practice can easily be answered

When it is considered that the mandible (from the median line to and including the maxillary mandibular joint) can be resected half of the upper jaw removed the tissues in the maxillary sinus and the bony structures enclosing it ablated the orbit exenterated and the frontal and ethmoid sinus cleared of disease without serious hemorrhage or great surgical shock by a single electrocoagulation operation then an idea is given of its potency and range.

If enthusiasm there be it is pardonable upon the basis of facts and matured appraisement. One who has seen the curative and cosmetic effects of an electrodesiccation operation upon epithelioma of the lower lip for example would not again seriously consider excising it by the older surgical method

FIG. 75.—Basal-cell epithelioma involving the ear parotid gland, surrounding tissues, the mastoid bone and the ear canal, extending almost down to the tympanum.

FIG. 76.—Demonstrating the fine control by the electrodesiccation method. One such operation was performed under ether anesthesia. Both facial nerve and hearing were conserved. Note cotton in ear canal for cleanliness and protection.

FIG. 77.—Sq uous-cell carcinoma, grade 3 of ear and mastoid region, including involvement f i ne.

FIG. 78.—R ult of combined electrocoagulation and radium treatment. No recurrence in 14 years atient still livin

Fig. 79.—Inoperable adenocarcinoma f the breast and axilla, with extensive metastasis to the lungs and mediastinum Too extensive to be treated by electrocoagulation, which was contraindicated because it would have been impossible to treat all the disease with safety to patient. Radium needles and deep x ray therapy were employed.

Fig. 80—The remarkable result show was obtained. This patient lived 3½ years following treatment, and finally died from further metastasis. This case is shown to stress the fact that electrosurgery has limitations.

Fig. 8 —An extensive scirrhous carcinoma f breast, with deep adhesions, but without metastasis. A type of breast carcinoma in which good result might be obtained by an electrocoagulation operation.

Technic.—As another example of technic a description of amputation of the tongue for advanced cancer by the electrocoagulation method has been selected, and it is as follows

If the case is far advanced with considerable emaciation it is proper to do a preliminary gastrostomy This has several advantages, namely, it permits of the building up of the patient's strength,

FIG. 82—Showing typical x ray lesion on hand of pioneer worker Lesion on hand is squamous-cell epithelioma. The electrodesiccation method has proved satisfactory for treatment of many similar lesions.

relieves the pain incident to swallowing and frequently results in a considerable reduction of the swelling and induration in the tongue and pharynx, following the rest given to those parts The tongue can then be readily electrocoagulated through its base and excised. Primary and secondary hemorrhages are unusual To diminish even the small risk it is wise to do a preliminary ligation of both external carotid arteries Ether anesthesia is employed the ether should be removed from the room and the fumes fanned away when the patient is fully anesthetized and before applying the current, else the vapor might ignite Should the operation be unusually prolonged and should the

patient show signs of regaining consciousness it may be temporarily discontinued as often as required while ether is again administered Frequently the operation is of such short duration that the use of ether a second time is not necessary Scopolamine 1/100 grain and morphine, ¼ grain may in some instances be used hypodermically one hour before the administration of ether Less ether will then be necessary and the immediate postoperative discomfort will thus be minimized.

Since electrocoagulation is produced by a current of relatively high amperage and low voltage an indifferent electrode placed on some part of the patient s body is necessary to complete the circuit This

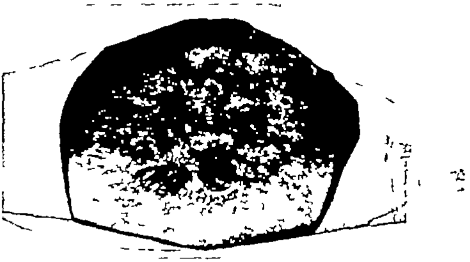

FIG. 83.—Showing squamous-cell epithelioma in skin of abdomen, a late result of x ray treatment fo fibroid tumo of the uterus. This was before the days when dosage, character of rays, and filtration were well understood. A coagulation operation cured this patient, and complete healing was accomplished without skin grafting.

electrode may be made of block tin or some other flexible metal or a moistened electrode made for example of asbestos or heavy towels which is in turn covered with some metal These electrodes should measure about 8 x 10 inches more or less depending upon the size of the patient. The indifferent electrode selected should be placed low down on the back of the patient the weight of the body holding it in place and insuring a good contact A good contact at all points is important, else sparking to the body might cause a localized high frequency burn

After separating the jaws with a mouth gag a heavy silk suture is passed through the tip of the tongue from side to side by means of which the organ is drawn well forward. The coagulation needle is then brought in contact with the dorsal surface of the tongue as far back as is necessary and the current turned on either by the operator

by means of a foot control, or by an assistant on signal The needle is slowly moved across the tongue and after the surface is coagulated the needle is carefully inserted into the tongue to the proper depth at different points, allowing electrocoagulation to take place as the needle penetrates This having been thoroughly accomplished, the tip of the tongue is elevated by means of the attached suture, and a straight sharp sewing needle of proper length is substituted for the curved needle previously used The frenum is then coagulated, and the electrified needle is inserted between the tongue and the floor of the

FIG. 84.—Small round-cell sarcoma involving tissue of the forehead and frontal bone, and extending through into the frontal sinus and upper and lower eyelids of both eyes. Vision lost through mechanical closure of lids.

FIG. 85.—Electrocoagulation not indicated owing to involvement of such structures as would result in loss of vision. Radium needle treatment employed with excellent result. Showing appearance three weeks after treatment.

FIG. 86.—Showing final result. Patient lived three and one-half years after treatment and finally died from extension of disease to the brain.

mouth. When electrocoagulation is again completed curved scissors may be used to cut through the electrocoagulated area on both surfaces and the tongue is then separated from its attachments and removed

After Treatment.—The after-treatment consists of simple antiseptic mouth washes and the application two or three times daily of a weak solution of hyposulphite of sodium which sterilizes deodorizes and tends to keep the slough free from maceration. Care should be taken not to remove the slough prematurely, else secondary hemorrhage might occur Such a major electrosurgical operation should be performed in a well-appointed operating room using the same preparatory technic as in any surgical operation though the necessity for sterilization is not as great when the electrosurgical methods are employed as when the cold scalpel is used

FIG. 87.—Mixed-cell sarcoma of the shoulder. Recurrence after two surgical excisions.
FIG. 88.—Result of combined electrodesiccation and radium treatment. Patient lived 8 years without recurrence.

FIG. 89.—Showing typical recurrence of melanotic sarcoma after surgical excision. The local disease in this case was controlled by employment of the electrodesiccation method when new foci appeared. The patient lived f 5½ years, and finally succumbed to metastasis to the lungs.

Hemorrhoids and Other Rectal Lesions

The electrodesiccation method has proved most satisfactory for the removal of internal hemorrhoids fissures fistulas papillomas, ulcers and localized malignant lesions of the rectum. The following technic for hemorrhoidectomy is almost identical with that of the clamp and cautery operation except that electrodesiccation is used as the active agent instead of the cautery

Technic.—The usual preparation of the patient is carried out. Local infiltration anesthetization by classical technic may be employed

Fig. 90.—Showing a case of melanotic sarcoma in which a radical coagulation operation was performed. While not successful in absolutely controlling the disease, the operation delayed its progress, prolonged the life of the patient, and decreased the pain.

although in some supersensitive individuals a general anesthetic, preferably ether is used. Caudal anesthesia is preferred by some operators. After stretching the sphincter muscle sufficiently each hemorrhoid is pulled down in turn by means of suitable tenacula and the pile is clamped at its base in the direction of the muscle fibers which are at right angles with the anus The pile is then electrodesiccated (by the technic described for other lesions) down to the clamp The clamp is then removed and the hemorrhoid is permitted to slough away or it may be excised at once not quite down to the clamp The latter method is preferred Postoperative hemorrhage is not greatly to be feared there is no resulting cicatricial contraction, and as a rule postoperative discomfort is not great. In some cases however it is greater than n others Patients should be hospitalized and remain in bed for a few days as a safe precautionary measure The electro-

desiccation method for removing hemorrhoids is an advance over the Whitehead ligature clamp and cautery operations and the injection methods for the radical cure of hemorrhoids

The electrodesiccation technic described has been found to be more satisfactory for hemorrhoidectomy than the more intense electrocoagulation method The practice of passing the bipolar high amperage current (diathermy) through a metal clamp after the hemorrhoid is engaged in the clamp is not as satisfactory as the method described owing to the possibility of unnecessarily electrocoagulating tissues adjacent to the hemorrhoids the greater inflammatory reaction and possibility of subsequent contracture of the lumen of the rectum.

Breast Amputation by Electrosurgery

In some cases of ulcerated cancer of the breast when there is not sufficient healthy skin to permit approximation by suturing the electrocoagulation method may be used This has the disadvantage of leaving an open wound which must necessarily heal by granulation. It has the advantage however of immediately ridding the patient of a discharging malodorous ulcerating growth with almost immediate relief from pain It is astonishing how a large healthy ulcer in the mammary gland and other locations thus produced by electrocoagulation will heal by granulations without the necessity of skin grafting after removal of the disease down to a healthy base A note of warning is sounded to use care that the electrocoagulation is not extended through the tissue in the intercostal spaces lest there be a slough through into the pleura or pericardium

I am indebted to Dr Harry E Mock of Chicago Ill for the following data upon breast amputation by the high-frequency knife which has a wider field of usefulness in breast work than has electrocoagulation.

Technic.—In breast amputations the skin incision I [Dr Mock] use is similar to that described many years ago by Halstead At first I made this skin incision with the high-frequency knife but in my experience the healing of the skin margins is somewhat slower than when it is made by cold scalpel Therefore in more recent years the incision is outlined by the scalpel and barely passes through the skin The few bleeders encountered are grasped by small hemostats and are later sealed by barely touching the hemostat with the point of the electrode needle with the current changed to a partly electrocoagulating current. The incision is now carried through the alveolar tissue, fascia, and muscles down to the ribs and a clean dissection of the breast including the pectoralis major and the pectoralis minor muscles is made upward to the axilla. The smaller vessels are usually electrocoagulated during this cutting procedure but the larger vessels are grasped by hemostats before the tissues are severed with the cutting current The cutting current is then turned to an electrocoagulating current, and the hemostats are touched by the electrode until the vessels are thoroughly electrocoagulated Seldom

are more than two or three ligatures used throughout the entire operation of breast amputation and removal of glands in the axilla The breast and pectoralis muscles are now turned downward toward the posterior axillary line after the muscles are severed near their insertion to the humerus this completely exposes the axilla. A careful blunt dissection of the axillary glands fat, and connective tissue surrounding the axillary artery and vein and the lower branches of the brachial plexus is now carried out in the usual way with the Kocher dissector and tissue forceps. Just as soon as this dissection is sufficiently removed from the axillary artery and vein, the high frequency electrode is used in carrying out the further dissection of the axilla. Every gland and every bit of fat are removed from above and behind and internally and externally to the vessels and from behind the margin of the latissimus dorsi and downward to the most dependent angle of the axilla. The breast the muscles, the glands and the fatty tissue from the axilla are now completely removed and sent to the laboratory

A soft rubber drain is inserted through the skin flap into the axilla, its exit being at the most dependent portion of the latter The skin incision is then closed with silkworm-gut and silk after making sure that hemostasis is complete

Advantages—The above operation can be completed by me in approximately two-thirds of the time consumed in the breast amputation with the scalpel and the ligation of all bleeders.

The majority of these patients have practically no complaint of pain following the operation by this method Practically every observer has remarked upon the decreased pain when electrosurgery is used.

Histologic studies of the blood vessels and lymphatics show definitely that these are sealed by the cutting current. The fear, therefore, of disseminating cancer cells during the operative procedure is practically eliminated.

Disadvantages.—Hemorrhage following breast amputation has not occurred in any of my cases. However in one case of removal of a benign tumor from the breast by electrosurgery a hemorrhage did develop

In about 50 per cent of the cases, especially if they are fatty subjects I must admit that there is a great deal more collection of serum in the wound following this method Great care must be exercised when one passes an electrocoagulating current through a hemostat for the purpose of hemostasis. If the hemostat touches the skin the latter will be electrocoagulated or burned and will cause considerable delay in the healing of the incision at this point

In all my breast amputations, whether by the cold scalpel or the high-frequency knife I have had only one surgical death that is death following and traceable to the operation. This case developed a complete pneumothorax followed by a streptococcus infection with death at the end of one week following the operation At autopsy there was revealed a small opening in the anterior portion of the axilla between the third and fourth ribs, and extending completely into the pleura. There are two possibilities for this small ulcerated opening First it could have been caused by pressure from the end of t e drainage tube, as the tube lay exactly in this position second, it could h e been caused by a slough developing at the point of coagulation

of a bleeding vessel Since this catastrophe I have guarded against and have warned others against, the use of too strong an electrocoagulating current over the intercostal spaces.

Results.—I have used electrosurgery in breast amputations for a period of five years. I am positive that more patients are remaining free from metastasis during this five-year period than during any other five-year period of my experience However the time is too short to give any statistics or arguments which would be of value in the ultimate end-results. Even if the percentage of recurrences or metastases proves to be equal to the series of cases in which the cold scalpel was used, yet the increased rapidity and ease of this operation by means of electrosurgery and the reduction in pain and shock by this method definitely warrant its use

FIG. 91.—One of two similar cases of anthrax infection treated the same day by the electrodesiccation method. These cases were referred from a bacteriologic laborat ry where the patients were ccidentally infected. Temperature at the time was 104.2 F (40 C.) Serum was employed to combat possible blood infection.

FIG. 9 —Rapid recovery in both cases after one electrodesiccation operation. Note good cosmetic result. Photograph taken one year after treatment.

Thyroidectomy with Electrosurgery

Evidence is accumulating that electrosurgery is a valuable adjuvant in thyroidectomy Its use in this condition was first described by Mock of Chicago who gives the following description of this operation. [*J A M A* 94 1365 1368 (May) 1930]

Technic.—The usual skin incision is made in the neck either with a scalpel the numerous small vessels which are always cut being grasped with small hemostats, or with a purely cutting current the bleeders likewise being grasped with hemostats When the incision is made with the active

or cutting electrode it must be done quickly and accurately in order to obtain a clean-cut incision through the skin.

The next step is to seal the numerous small bleeders exposed by the skin incision The assistant in charge of the generating machine changes the switch from a cutting to a searing current and the operator then touches each hemostat in turn with the point of the active electrode (held in the pistol grip) The current passes down the hemostat and seals the end of the vessel thus eliminating the use of a ligature Throughout the entire operation practically all vessels are sealed in this manner instead of being ligated The usual exception is the superior thyroid arteries which as a further precaution may be both ligated and sealed

Fig 93 —Nevus pigmentosus occurring o the abdomen of a young woman Radium treatment in other hands was unsuccessful, serving only to complicate the case.

Fig. 94.—Result obtained by electrodesiccation after radium failed.

The assistant next turns the switch back to the cutting current, and the operator proceeds to expose the thyroid gland The incision is now con tinued with the cutting electrode down through the platysma muscle, and the skin and the platysma flaps are dissected upward and downward the usual distance These skin flaps are retracted by small nonconducting retractors made of a hard fiber The cervical fascia is now exposed and is incised down the middle. It is then freed from the capsule of the gland by blunt finger dissection or by a Kocher dissector and is retracted laterally along with the sternohyoid muscles by nonconducting retractors When in the case of a very large goiter it is necessary to incise this muscle on one or both sides, this incision is likewise done with the cutting current In many cases in which the muscles have not been overdistended by a large goiter thus enhancing the ease of their retraction, it is necessary to make a transverse in ision as well as the vertical one, and to turn back the four muscular flaps in order to expose the goiter

The goiter is now mobilized by gently passing the finger around its borders, but no undue traction is used to deliver it into the wound where it can be attached more readily Clamps are placed on the superior and inferior thyroid arteries first on the right lobe and later on the left The gland is now attacked in its superior lateral aspect, the combined cutting cooking current being used for dissection instead of the sharp scalpel and hemostats. Occasionally a vessel will bleed and it is necessary to grasp it with a hemostat, but as a rule not more than four or five hemostats are employed on each lobe and these, with the exception of the superior thyroid arteries are sealed by passing a cooking current down the hemostat. Such a small amount of this current is necessary but these vessels are sealed not electrocoagulated, and there is no area left behind to slough as is the case when tissue is thoroughly electrocoagulated

Both the procedure advocated so strongly by Crile of leaving a small layer of gland behind along the lateral margins and a small film of gland tissue across the trachea, and the method advocated by Reinhoff and others of opening the internal capsule of the gland and dissecting this off the anterior surface of the goiter and then removing the latter by an intra capsular dissection have been used When the latter method is employed an effort is made to dissect the capsule away from the gland retracting it laterally but performing this dissection by means of the electric current rather than by a blunt incision.

The chief purpose of this entire method of attack is to seal not only the blood vessels, but the lymphatics just ahead of the incision, thus preventing the escape of the thyroid toxins into the circulatory (blood and lymphatic) system, with the subsequent severe reactions not infrequently seen following these operations. Therefore when the goiter proper is reached every effort is made to avoid the use of scalpel scissors or blunt dissector These are replaced by the cutting-sealing electric current, exactly as is done in the case of a malignant growth in which the desire to seal the blood and lymph channels is even more important

The bed from which the goiter is removed is now carefully inspected any bleeding points that appear are sealed with the current, and the re maining edges of the capsule are approximated with plain catgut A drain of soft small rubber tubing is inserted as a routine In three cases closure has been effected without drainage, but in one of these there was a con siderable collection of serum. In one case a small hemorrhage developed which was readily controlled by pressure dressing The skin is closed by fine silk sutures and the drain is removed in from 24 to 48 hours.

Anesthetic.—The anesthetic of choice in these cases of goiter is 0 5 per cent procaine hydrochloride used locally One hour preceding the operation the patient is given morphine sulphate 1/4 grain (16 mg) and scopolamine, 1/150 grain (0.4 mg) With this anesthetic no precautions need be taken on account of the electrical current

Nitrous oxide gas may be used without undue fear of an explosion and ether can be used. In the latter two cases a wet flannel roll is placed just below the lower edge of the mask, and further protection against the fumes of the ether reaching the electric spark is provided by a rubber apron placed over the anesthetic frame and held tightly by clips against the skin of the cheeks and chin. In all but one of the cases in this series local anesthesia was used.

or cutting electrode, it must be done quickly and accurately in order to obtain a clean-cut incision through the skin.

The next step is to seal the numerous small bleeders exposed by the skin incision. The assistant in charge of the generating machine changes the switch from a cutting to a searing current, and the operator then touches each hemostat in turn with the point of the active electrode (held in the pistol grip) The current passes down the hemostat and seals the end of the vessel thus eliminating the use of a ligature. Throughout the entire operation practically all vessels are sealed in this manner instead of being ligated. The usual exception is the superior thyroid arteries, which as a further precaution may be both ligated and sealed

FIG. 93.—Nevus pigmentosus occurring on the abdomen of a young woman. Radium treatment in other hands was unsuccessful serving only to complicate the case.

FIG. 94.—Result obtained by electrodesiccation after radium failed.

The assistant next turns the switch back to the cutting current and the operator proceeds to expose the thyroid gland. The incision is now continued with the cutting electrode down through the platysma muscle, and the skin and the platysma flaps are dissected upward and downward the usual distance. These skin flaps are retracted by small nonconducting retractors made of a hard fiber The cervical fascia is now exposed and is incised down the middle. It is then freed from the capsule of the gland by blunt finger dissection or by a Kocher dissector and is retracted laterally along with the sternohyoid muscles by nonconducting retractors. When in the case of a very large goiter it is necessary to incise this muscle on one or both sides, this incision is likewise done with the cutting current. In many cases in which the muscles have not been overdistended by a large goiter thus enhancing the ease of their retraction it is necessary to make a transverse incision as well as the vertical one and to turn back the four muscular flaps in order to expose the goiter

series that has shown the least evidence of a postoperative thyroid toxicosis. It would seem logical to ascribe this to the same sealing of the blood and lymphatic channels, thus preventing the escape of toxic substances from the cut thyroid gland.

I am not yet ready to say that this will be my method of choice in every case of thyroidectomy I am however convinced that it is by far the most rational procedure in all cases of malignant growths susceptible to being attacked by electrosurgery For the same reason it would seem an equally rational procedure in malignant conditions of the thyroid or in severe cases of toxic or exophthalmic goiter

Disadvantages—1 The machine for the generating of this electrical surgical current is large and cumbersome and is transported from one hospital to another with great inconvenience It is an expensive apparatus and therefore will usually be purchased only by surgeons or hospitals interested especially in malignant conditions or by those who may come to recognize its value in thyroidectomy Its general usefulness is therefore greatly limited.

2 The surgeon must have at hand a carefully trained assistant who understands the mechanism and who can manipulate the various switches that modulate the current from the light cutting stage, through intervening stages, to a heavy electrocoagulating current. Unfortunately there are only a few persons trained to operate this particular machine

3 It requires considerable experience to use just sufficient current to make a clean-cut incision in the skin that will heal as readily and with as little remaining scar as follows a properly executed scalpel incision With practice, however this can be accomplished If too strong an electrocoagulating current is used in sealing the blood vessels, one may have a greater amount of serum drainage than is the rule when hemostats and ligatures are used Here again experience with the current is necessary to overcome this difficulty

4 Care must be used not to allow the current to come in contact with a hemostat lying across the skin or a metal retractor otherwise, cooking of the skin or of the tissue under the retractor will follow to a degree depending upon the strength of the current This of course, can be easily avoided.

Conclusions.—1 The value of electrosurgery in the removal of malignant growths of the breasts and other locations where it is possible to attack them by this method has been enthusiastically endorsed by all surgeons familiar with its use There is no question that this method prevents the escape of carcinomatous cells into the blood and lymphatic streams It reduces the amount of shock and gives better hemostasis.

2 In thyroidectomies this method prevents the escape of toxic material into the general circulation during the operation, resulting therefore in a convalescence devoid of the severe reaction often seen in these cases. It shortens the operative period by eliminating the ligation of a large number of vessels. It gives a convalescence almost completely free from pain.

3 It has the disadvantage of a cumbersome machine the need of a trained assistant to manipulate the machine and the added expense of these two items But in spite of these disadvantages this method should

Number of Cases and Postoperative Course.—Only 15 thyroidectomies have been performed by means of the electrosurgical current. The method is still being studied and compared with the immediate and late results in patients operated on by means of the scalpel with the usual technic. All but 3 of these 15 cases were extremely severe types of hyperthyroidism, with marked loss of weight rapid irregular pulse rate, and, in four of the cases marked involvement of the heart The basal metabolism rates varied from 35 to 89

During the immediate postoperative convalescence I have marveled at the almost complete absence of pain in every case at least 10 of the patients have been completely free from postoperative complaints In no case has the temperature been elevated above 101.4 F (38 5° C.) this rise occurring in two cases on the second postoperative day Six of the other cases showed an elevation in temperature to 100 F (37 7 C.) on the second and third days with normal temperature during the remainder of the convalescent period Five patients showed normal temperature throughout the postoperative period of convalescence.

The basal metabolism rate in all but three of these cases receded to below 10 + by the end of three weeks. Only one patient showed a high rate four months after the operation. He had a preoperative rate of 59 + and four months later the rate was 35 + although from a clinical standpoint he could be classed as having recovered One patient in the series had a rate below — 10 namely — 12½

Advantages—Although this is too small a series of cases to justify positive conclusions a few definite advantages are apparent

1 The time of the operation is definitely shortened by this method through the sealing of the bleeding vessels rather than the use of the time-consuming method of applying ligatures.

2 In every case, even in the most serious with marked cardiac involvement, there has been a complete absence of postoperative shock. One patient was in such an extreme condition that the family physician called at the hospital just before the operation and begged both the patient and his wife to forego the operation stating that he would surely die if submitted to this ordeal yet the patient made an absolutely normal recovery free from all shock and pain

3 A convalescence so free from postoperative pain that even the patient remarks about the complete lack of suffering is almost the universal rule. This result occurring in a group of patients who are usually emotional given to complaints, and often seeking sympathy is especially noteworthy

4. When one has used the electrosurgical method in the removal of a large number of malignant growths in breasts tongues, lips, and parotid glands one becomes deeply impressed with the bloodless field, the absence of postoperative shock, and the freedom from postoperative pain The greatest impression, however and the greatest sense of security lie in the sealing of blood and lymph channels simultaneously with the incision in and around the malignant growth. The old fear of opening up channels for the escape of carcinomatous cells to some other parts of the body is at once eliminated to a great extent.

The same principle holds true in the removal of a very toxic goiter by the electrosurgical method. There has been no case thus far in this small

adds a complication to an already highly complicated procedure. Yet, in making a review of the early histories for purposes of this present communication I find it expressly stated over and over again that the particular procedure in question though an extremely prolonged and arduous performance, was one which, without the electrosurgical adjunct, would have been impossible to carry through to a safe conclusion.

During the two years just elapsed since we hesitatingly began to employ the currents in craniocerebral surgery 547 operations for tumors have been performed. Though for some of these operations the electrical methods were not essential, there were few of them even when no tumor was found

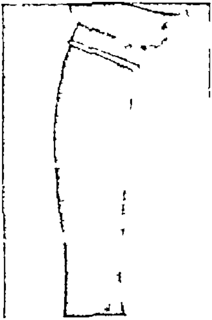

FIG 97—Showing a tattoo mark treated by electrodesiccation. The scar noted was hitherto caused by an attempt at excision.

FIG. 98.—The result obtained. Electrodesiccation has been found satisfactory for the removal of tattoo marks.

in which they could not advantageously be employed. The currents are useful even for such trifles as brushing the surface of the dura with the ball electrode in order to seal the torn meningeal veins, from which persistent oozing may sometimes try one's patience or similarly for checking the persistently oozing points on the under surface of the reflected bone before its replacement, or for electrocoagulating some refractory vessel on the incised dural margin To be sure muscle implantation bone wax, and silver clips have long been used for these several purposes and they cannot be wholly dispensed with even now but on the whole electrical methods usually serve to accomplish the same ends more expeditiously

Nearly 20 years have passed since Pozzi announced to the Academy of Medicine in Paris a method for the cure of malignancy by the action of sparks from the terminal of an Oudin resonator a procedure termed ful guration," as Dr Bovie mentions in his introductory note Slowly and grad

be seriously considered in every case of a malignant disease of the thyroid and in extreme cases of toxicity with hyperthyroidism.

Dr Martin B Tinker of Ithaca N Y at a recent meeting of the American College of Surgeons, stated that he found the high frequency knife to be successful in goiter operations. He stated that 'electrosurgical outfits have been used by a number of outstanding surgeons in this country for a good many years, especially in the management of malignancy Their advantages have become apparent to many members of the profession and I believe that shortly

FIG. 95 —Nevus pigmentosus treated by the desiccation method.
FIG. 96 —Showing the good cosmetic result obtained.

an electrosurgical unit will be considered a necessary part of every modern operating room especially where much goiter surgery is done."

ELECTROSURGERY IN BRAIN LESIONS

Great advances have been made in the use of the various electrosurgical methods in brain surgery The following is quoted in abstract form from a paper entitled Electrosurgery as an Aid in the Removal of Intracranial Tumors by Dr Harvey Cushing which was published in *Surgery Gynecology and Obstetrics* December 1928

There is no gainsaying that the employment of the Bovie Unit or any other form of current generator as an aid to the removal of brain tumors

taking hemostasis that have largely put a stop to operating by the clock It has been equally slow to adopt the principles of electrosurgery which from a technical standpoint, are likely to be no less revolutionizing

At a recent meeting of the American College of Surgeons Dr Ernest Sachs of St. Louis Mo said that from his experience electro-

FIG. 101 —Angioma of the lower lip nursing child.

FIG 102.—Result f radium treatment which is preferred to electrodesiccation for angiomas of the lip especially in nursing infants.

FIG. 1 3 —Angioma angle f mouth

FIG. 104—Result of one office electrodesiccation operation, which treatment is preferred in adults.

surgical methods are indispensable in brain surgery for the principal reason that he found it possible almost entirely to give up the use of silver clips His summary is as follows

1 Electrosurgery is the most important addition to neurosurgical technic that has been devised in many years.

ually this procedure has been modified and extended until for the treatment chiefly of cutaneous lesions and of orificial malignancy it has gained enthusiastic advocates

Surgery is a conservative art It takes to novel methods reluctantly as an old dog to new tricks. It was slow to adopt the ligature, slow to adopt the principles of antisepsis slow to adopt the fastidious technic and pains-

FIG. 99 —Extensive keloid following burn

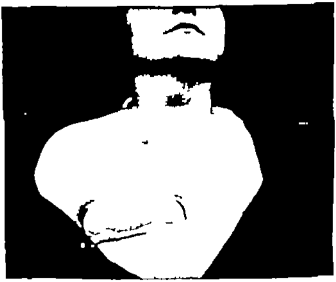

FIG. 100.—Result obtained by well-considered radium treatment, with careful planning of filtration and dosage This is the treatment par excellence for keloid. Electrosurgical methods should not be employed in keloid, since such treatment will make matters worse

the same result is a fact that depends entirely upon the individual's surgical technic. It should be emphasized again therefore that electrosurgery cannot *be said to have superseded the basic principles of osteoplastic cranial* operations and tumor removal

It has been our experience that one is likely to hurry the procedures of electrocoagulating vessels or incising brain tissue. As has been pointed out, the use of a strong current to electrocoagulate a vessel may cause it to explode and to defeat the object for which it is intended. It is certain that the electrodes are of no service whatever in a bloody field which does not allow one to see the bleeding or oozing point

It is of course understood that an electrosurgical apparatus should not be used during the administration of a general anesthetic. The possibility of an explosion is too factual to be dismissed consequently the operations in which the electrodes are used are performed under local anesthesia. The dis-

FIG. 97.—Port wine nevus.

FIG. 98.—Result of ultraviolet ray treatment by the compression method. This treatment is to be preferred to either radium or electrodesiccation in this type of case

advantage of a general anesthesia, such as ether in intracranial operations is well known so that the necessity of a local anesthetic in itself is of value. However it must be realized that many individuals are not suitable patients for the use of local anesthesia. In such circumstances we have taken the precaution of removing the ether bottle from the room and have placed a wet cloth between *the patient's face and the operative field while the unit* is in use.

We have satisfied ourselves that there are no untoward or disturbing complications due to the use of this apparatus in intracranial surgery As a matter of fact the immediate postoperative convalescence in all the cases in which it has been used has been smooth and uneventful We have never had to reëlevate a flap in this group of cases because of secondary hemorrhage neither do we believe that any greater amount of postoperative edema follows its use. In conclusion, we believe that

2 By means of this method brain tumors can be dealt with that have been inoperable heretofore and tumors that were operable can now be removed with greater safety

3 The technic of this procedure takes time to learn, and as our experience increases and its possibilities are realized more and more can be accomplished with it in the future. [*Surg Gynec Obst.*, p 505 (Feb) 1931]

FIG. 105.—Extensive cavernous angioma of cheek extending almost through into the mouth. The major portion of the lesion was covered by healthy skin but an elevated strawberry-colored surface angioma may be observed in the photograph.

FIG. 106.—Showing result of an electrocoagulation operation the blood lake was coagulated and later removed through the external angioma Note retrogression to normal with small uncontracted scar Four similar operations were successfully performed before radium was employed for such cases. Radium is now preferred because of less hazard.

The following relative to brain surgery, is kindly contributed by Dr Loyal Davis Professor of Surgery of the Northwestern University Medical School

There can be no doubt that the use of electrosurgery adds a complex piece of surgical equipment to a technic already dependent upon meticulous attention to detail for its success. The surgeon of course does not have to be acquainted with all the laws of electrical physics to employ such an apparatus successfully However a thorough acquaintance with its performance obtained upon experimental structures is necessary before one should attempt its use during a complicated surgical procedure. Even with such a preparation the advantages and limitations of its use are indicated more clearly by practice. That some surgeons may find it of more value than others to gain

not as greatly to be feared when the high frequency knife is employed as after the cold scalpel He further states that he has performed five laparotomies for the purpose of dividing extensive intra abdominal adhesions by the electrosurgical knife with no recurrence of the adhesions as evidenced by the permanent disappearance of the char acteristic discomfort caused by them In a recent communication Trowbridge stated that he had successfully performed nephrectomy and hysterectomy and had removed a renal calculus by means of the high frequency knife

Fig. 11 —Cavernous angioma and necrosis of bone from excessive radium treatment hitherto given by another physician Patient almost lost life from hemorrhage

Fig. 113 —Result of one electrocoagulation operation.

Electrosurgery in the Genito-Urinary Field

The same indications for electrosurgery exist in the genito-urinary as in the gynecologic field This can be extended in the male to pros tatectomy through a suprapubic opening by means of the high frequency knife Some surgeons have advocated employing a wire loop as the knife in the use of the high frequency cutting current for sever ing and removing the median bar of the prostate by way of the ureth ral route through an operating cystoscope as an improvement over the Bottini operation

Excellent results have been reported by surgeons who are in a posi tion to judge of the merits of electrosurgery in this field The suc cessful removal of papillomas from the bladder by means of the high frequency current through an operating cystoscope which was first described by Beers and verified by many others is impressive to those who have seen the operation performed The treatment of such lesions has been revolutionized by the advent of electrosurgical methods I have successfully stopped hemorrhage and removed numerous papil lomas of the bladder by the high frequency method The first one in

1 Electrosurgery is a distinct addition to the neurologic surgeon's armamentarium It does not however, completely supersede the well-established principles of osteoplastic cranial cerebral surgery

2 At present it may be employed to its greatest extent in the removal of meningiomas in particular to the relatively inaccessible meningiomas.

3 The improvement of the use of electrosurgery in the treatment of gliomas offers the possibility for its greatest contribution to the surgery of the nervous system.

FIG. 109.—Extensive cavernous angioma.

FIG. 110—Showing improvement during radium treatment.

FIG. 111—End result of radium treatment a method which is preferred to electrosurgical methods in this type of case.

Electrosurgery in Gynecology

Electrosurgical methods have a very definite value in a wide range of conditions of interest to the gynecologist. Among the minor lesions in this field which can be successfully treated by the electrodesiccation method are venereal warts leukokeratoses leukoplakia condylomas moles (simple and pigmented) chancroids angiomas some localized cases of pruritus (of nerve or eczematous origin) urethral caruncle urethral prolapse erosions and infected Bartholin s and Skene s glands lupus fissures fistulas of vagina and rectum polypi papillomas of the bladder (operating through a cystoscope or a suprapubic opening) papillomas of the vagina, cervix, and rectum erosions of the uterine cervix, endocervicitis hemorrhoids epitheliomas chancre (influencing the treatment and progress of syphilis) and carcinoma of the cervix in combination with radium.

The larger growths may be treated by the more powerful coagulation method The high frequency knife has a wide field of usefulness in pelvic surgery such as hysterectomy through an abdominal incision and evidence is accumulating that the future for this method is promising throughout the whole range of gynecologic surgery This is also true of surgery of the upper abdomen and thorax An interesting observation has been made by Trowbridge, that adhesions are

the lesion can be removed with the same ease and simplicity as though it were on the skin surface The wound will heal readily if the patient is normal and some notable results have been obtained

I have had under my observation a case of squamous-cell carcinoma which was treated by this method and the patient has been free from recurrence for 10 years In extensive carcinoma of the larynx, com

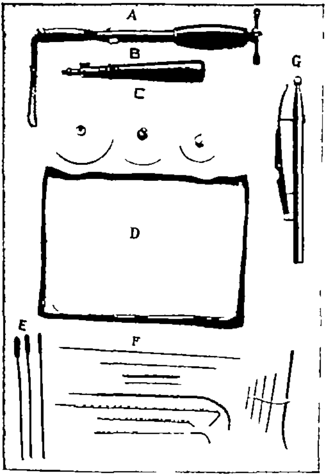

Fig. 114.—Showing some instruments employed in electrodesiccation and electrocoagulation

A. Metallic snare which can be used as the active electrode for electrocoagulation and removal of certain large pedunculated growths. Fig. 70 is an example.

B and C. Handle and metallic discs utilized as passive electrodes when localized destructive effects are desired. Fig. 70 is also an example The active snare was employed around the pedicle and the passive disc on top of the papilloma.

D Asbestos electrode covered with rubber on one side and duck on the other When moistened and placed on the back f the patient it serves as a satisfactory passive con ductor in electrocoagulation work.

E. Electrodes of copper suitable for electrocoagulation treatment of such conditions as endocervicitis or endometritis.

F A variety f needles employed as active electrodes f electrodesiccation and electrocoagulation work.

G Handle designed by Cooke to hold needles for electrodesiccation and electrocoagulation operations.

1910 was a bleeding papilloma almost the size of a hen's egg. The patient, an aged man, lived for seven years free from recurrence. I have found from experience, however, that unless the lesion is benign, it should be treated through a suprapubic incision and an opening into the bladder In this case other methods may be employed in conjunc tion with the electrosurgical method

ELECTROSURGERY IN EYE SINUSES EAR, NOSE, THROAT, AND LARYNX

Electrodesiccation may be employed in the following eye lesions without causing a contracted scar neoplasms of the eyelids canthi, bulbar and palpebral conjunctiva, such as epitheliomas sarcomas, warts, moles, nevi, dry granular conjunctivitis, trachoma, leukoma, refractory corneal ulcers lupus, permanent removal of cella from eyelids when indicated xanthoma, chronic local infections, etc. When complete exenteration of the orbit and adjacent sinuses is indicated or when adjacent bony structures are involved with disease electrocoagulation, in many instances may be relied upon to accomplish superior results provided the technic is thoroughly understood Great care must, however be taken to avoid injury to orbital bones, else the dura will be exposed and meningitis will result

The same types of lesions noted in the preceding paragraph, occurring on or in the ear canal, may be successfully treated by electrodesiccation or electrocoagulation the choice of method depending upon the extent of the disease It might be noted as a matter of interest and to illustrate the delicate action of the current, that small granulations of the tympanum may be removed by electrodesiccation without injuring that delicate structure, so great is the refinement of its control.

Lesions on the nose of the same type mentioned above may also be successfully treated by electrosurgical methods.

Electrodesiccation has been found useful in the removal of hypertrophied turbinates polypi, papillomas epitheliomas etc. of the nasal mucous membranes without causing the hemorrhage incident to the use of the cold scalpel

There are numerous indications for electrosurgery in its different forms in the throat, such as tonsillectomy removal of papillomas lupus, leukoplakia, and certain malignant lesions. The electrodesiccation method is satisfactory for the removal of accessible papillomas of the vocal cords This operation can be performed by either indirect or direct vision through a laryngoscope

Cancer of the larynx, however should not be treated through the mouth, owing to impossibility of doing complete work, and also owing to the hazard of injuring normal structures. It is preferred that a preliminary tracheotomy be performed and after that a laryngotomy by a longitudinal incision. In this manner the lesion can be properly exposed an l palpated to determine its location and character Then

however regarding the value of this method some commending and others condemning it. This has caused confusion in the minds of those who are sincerely seeking authentic information.

Fig 115—Section of basal-cell epithelioma removed before the application of electrodesiccation, showing bulky masses of infiltrating basal cells.

Fig 116—Section from the same growth as Fig. 115 showing the result of electrodesiccation treatment The cellular masses are definitely shrunken and the nuclei condensed and elongated.

plete laryngectomy is sometimes indicated, and in this work the elec trosurgical knife may be found to have a field of usefulness.

Tonsillectomy by Electrosurgical Methods

May I state at the outset that it is the opinion of conservative laryngologists that electrosurgical methods will not entirely replace the operation in use for many years, owing to satisfactory results obtained with the latter in the average case. This is probably true, but it is also quite well known that in certain instances there is a distinct contraindication to the open operation. If therefore, electrosurgical methods can be used in such cases with the hazard minimized, then there is a valid reason for including them among the methods to be considered by laryngologists when unusual conditions exist.

Experience with electrosurgical methods in tonsil work has been multiplying and while discounting the ultra laudatory opinions of the overenthusiasts it now appears safe to say that some electrosurgical methods may be relied upon as worthy substitutes for the open operation in cases where there is a distinct contraindication to its use especially in the case of adults This is true, provided a proper and standardized technic is employed Three electrosurgical methods have been advocated for tonsillectomy, namely the high frequency snare electrocoagulation (diathermy), and electrodesiccation, which in turn will be briefly discussed

High Frequency Snare.—A few laryngologists have suggested the use of the high frequency snare for tonsillectomy The same current used for cutting (bipolar) is passed through a metallic snare, and the tonsil is removed by the same technic as in the cold snare opera tion, except that the current is used while the snare separates the tonsil from its bed. Its advocates claim that the possibility of hemor rhage is less and that it has the further advantage of sterilizing the operative field. While it undoubtedly has these advantages it has not been adopted for general use because of the greater care necessary for the proper control of the current, lest other structures in the throat be damaged. In common with any known method the danger of hemorrhage is, however, not entirely avoided regardless of primary capillary sealing. It would not be entirely safe to depend upon it permanently to seal the normal or anomalous larger vessels that may be encountered It is doubtful what the future appraisement of this method will be, but at the present time, at least it is not as popular as the electrocoagulation (diathermy) or the electrodesiccation meth ods (unipolar) for tonsillectomy

Electrocoagulation (Diathermy) —The electrocoagulation effect produced by the bipolar d Arsonval current of high amperage and low voltage has been widely employed during recent years for the removal of tonsils with a fair measure of success. Published opinions differ,

Method No. 2 is perhaps more generally in use than the others and is quite satisfactory if correct technical rules are observed.

Method No 3 bids fair to be popular also and those who employ it believe it satisfactory

FIG. 117—Section of basal-cell epithelioma of the cheek treated by electrodesiccation. The devitalized cells ppear as long slender threads—"mummification necrosis.

FIG. 118—Squamous-cell epithelioma treated by electrocoagulation, showing an ex tensive area resembling hyalinization and several thrombosed blood vessels. The tumor cells seem to have fused into a structureless mass

Paradoxical as it may seem, the different estimates of its value may all be correct, each depending upon the point of view This is explained by the fact that high frequency currents are characterized by, and subject to, great flexibility, both as regards the mode of production and also in the effect produced by them in the tissues A wide range of effects can therefore be obtained from their use, depending to a great extent upon the construction of the apparatus which generates the current in such details as the capacity of the condensers the number of windings and the thickness of the wire in the primary and secondary coils and in the solenoid to produce the proper inductance the character of the spark gap to insure the correct resistance, and lastly the technic of application.

For example ten operators, conceivably of equal ability and experience, might in all sincerity and accuracy report their findings but with no two of them exactly agreeing This is explained by the fact that none of them employed the same electrical factors nor the same technic in their work Thus the views of diverse nature are explained

In the course of development of any important invention, a condition of uncertainty is to be expected for a time until all factors are standardized toward the end that maximum efficiency will be attained by all employing them.

There are four methods in use for employing electrocoagulation (diathermy) in tonsillectomy

1 Destroying the tonsil as completely as possible at one operation employing an active needle electrode, and a passive metallic electrode on the back of the patient.

2 The removal of the tonsil in small portions in a series of treatments employing an electrically activated straight or hooked needle as the active electrode Multiple punctures in the tonsils are thus made and the indifferent electrode is placed upon the back of the patient.

3 The use of a metallic ring electrode which encircles the tonsil and when pressed inward exposes the tonsil to view, and also acts as the indifferent electrode The active electrodes are straight or hooked needles insulated except at the point, and the tonsils are removed little by little in a series of treatments, also by means of multiple punctures

4 The removal by means of two insulated hooked electrodes clamped together like a tonsil forceps and used at the same time, each carrying the current from opposite sides of the high frequency machine. By this method the tonsils may possibly be removed by one operation or better by a series of operations.

Method No 1 has been discarded by most operators because the inflammatory reaction is too great and the danger of destroying adjacent structures in the throat and of secondary hemorrhage is to be seriously considered as a possible hazard. It is therefore not recommended for general use

A whole gamut of effects may be produced in tissues by the various manifestations of electrical currents some of which are desirable for the treatment of certain lesions though contraindicated for others

I prefer to speak in definite terms of effects when possible, rather than of general methods For example the term drugs will help little in prescribing for a definite ailment whereas digitalis" can instantly be recognized as the particular "drug' to be administered in certain heart lesions The use of such terms as electrosurgery diathermy endothermy etc though proper in their place as general terms is therefore analogous to the use of the term "drugs which is indefinite in description of the particular drug actually employed whereas elec trodesiccation selected from a wide range of thermic electrical effects is a known entity like digitalis " and can be standardized for definite uses, one of which is for the successful removal of tonsils as well as certain other lesions before mentioned Electrocoagulation can likewise be distinguished from electrodesiccation with its definite indi cations and again the effect of the high-frequency knife upon tissue is dissimilar to either though in turn of value when it would be improper to use the other electrosurgical methods

It can therefore be seen that general terms are not conducive to a close understanding among scientific observers while standardization of methods in terms of effects and special technic will permit of duplication of results by different surgeons Out of the range of effects of applied electricity for surgical uses, electrodesiccation electrocoagulation and the high frequency knife have up to this time been found by experimental studies and clinical use to be more practical and useful than others thus far recognized

The harnessing of Nature s mysterious force by patient workers in the surgical field for the alleviation of human suffering is an achieve ment comparable with the greatest in surgical annals This sentiment has been voiced by some of the most critical minded of our profession.

Method No 4 seems a rational procedure, but its real value has yet to be demonstrated since so few laryngologists have thus far employed it.

Inquiry regarding removal of tonsils by the series treatment method among experienced laryngologists reveals that complete work is seldom accomplished in less than six treatments to each tonsil, in periods varying from seven days to two weeks between treatments. Some operators employ as many as 20 to 25 treatments Seldom is complete removal accomplished in any case in less than three months, and it sometimes requires six months or more It would seem that such prolongation of inflammation would be objectionable, but I am told by those who employ it that patients do not object to it.

All four methods have been fully described in current medical literature which is readily available, hence no attempt will be made to enter further into discussion of them in this chapter

In fairness to all may I state that these methods no doubt are successfully employed by capable men who have studied and applied them but, in common with any method designed for a definite purpose, some disadvantages are almost sure to exist.

Electrodesiccation.—From my experience with the use of all types of high-frequency currents for general surgical purposes for nearly 25 years I prefer the unipolar current of low amperage and high voltage for the removal of tonsils. May I therefore not be accused of bias if I differ somewhat from those who prefer any form of the bipolar high amperage and low voltage current (diathermy)

My growing impression is that electrodesiccation possesses fewer disadvantages and that it is more suitable for delicate throat work, than electrocoagulation (diathermy) inasmuch as there is better control with electrodesiccation the inflammatory reaction is slighter there is, I think less resulting fibrotic change the hazard of secondary hemorrhage is less to be feared the natural contour of the tonsillar fossa is better maintained the work is completed in fewer treatments, and the results are all that can be expected of any method.

Analysis of adverse reports concerning electrodesiccation in tonsillectomy reveals misunderstanding of the method and the employment of an improper technic

Electrosurgical methods for tonsillectomy should be practiced by laryngologists when indicated in complicated cases, but to insure the best results careful study and mastery of technic are necessary, else they will be disappointed with results.

Conclusion

The term *electrosurgery* is a broad one, expressing so many ways and means of applying various forms of electrical energy for the removal of abnormal tissue as often to cause confusion in the minds of those seeking reliable information

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CHAPTER TWENTY-ONE

ELECTROSURGERY AND OTHER PHYSICAL THERAPY MEASURES IN UROLOGY

F G Harrison M.D

Papilloma of the Penis

Verrucae acuminatae known commonly as venereal warts, although by no means always associated with any venereal disease are caused by irritation from some source usually from the prepuce. They are an overgrowth of the papillary layer of the skin or mucous membrane

They are mostly papillary in type and composed of epithelium which is readily transplantable to produce neighboring buds They may resemble epitheliomas or condylomas from which they must be differentiated

Correction of the irritation, whether from uncleanliness or discharges often causes disappearance Balanitis and phimosis must be corrected to prevent recurrence and this may necessitate circumcision.

While the ordinary treatment is the application of nitric or trichloracetic acid if not applied carefully and the excess mopped the surrounding mucous membrane is likely to be destroyed

The most satisfactory results are obtained by applying 10 to 20 per cent cocaine solution directly to the growth. After allowing a few minutes to elapse for the anesthetic to take effect a fine needle electrode is introduced at the base of the growth and it is destroyed using the monopolar high frequency and a low current.

A dusting powder and a dry dressing may be applied the warts either dropping off with treatment or in a few days

Chancroid

Any genital ulcer is regarded as a chancre until proved otherwise While the incubation period and the clinical characteristics may be such as point to a chancroid it is the golden rule that no treatment should be started until an absolute diagnosis is made The dark field examination for *Treponema pallidum* is positive in well over 90 per cent of untreated cases on the first examination For those sores which have received local treatment, especially preparations of mercury it is essential that all this be removed and the suspected ulcer cleansed and bathed in normal salt solution by repeated applications The

and with progression may break down and discharge pus from secondary infection or become a lesion like the initial focus

As epithelioma is uncommon before the fortieth year the diagnosis is made by exclusion. Biopsy is not recommended unless just prior to operative procedure as it has a tendency to promote metastasis

Similar to cancer elsewhere in the body the prognosis depends largely upon an early diagnosis with prompt and efficient treatment The later in life the condition develops the slower it seems to grow Prognosis is good if seen early and while it has been stated that should inguinal lymph node involvement occur cure is doubtful yet many are reported

Roentgen rays surgery diathermy and radium are the agents employed in the attack, either alone or combined but it depends upon the site and duration to some extent. Surgeons have stated that the epithelioma involving the glans or distal third of the penis may be treated by partial amputation but that which extends to the middle or proximal third demands extirpation

Preoperative roentgen-ray therapy of not more than one treatment is always advised. A preliminary block dissection of the inguinal glands is carried out prior to the radical surgery on the penis These glands may be destroyed by diathermy by placing the flat disk active electrode over the glands after exposure by the skin incision and slowly heating until the gloved finger cannot be borne on the tissues and with repetition Due care must be given to the femoral vessels which lie beneath.

The partial amputation is carried out with due respect for the skin flaps and placing and suturing of the cut urethra to prevent contracture and stricture formation of the new meatus

Complete extirpation is performed in the same manner with the new urinary meatus brought out to prevent stricture formation

Intensive postoperative roentgen ray therapy is routinely advised Complete emasculation is rarely employed and in recent years there seems to be a tendency whether warranted or not, to avoid the knife because of discouraging resultant metastasis and to employ measures that produce no mutilation with tendency to regional metastasis

Diathermy has been used in the treatment of epithelioma employing the bipolar current with the inactive electrode beneath the sacrum and a flat disk active electrode General anesthesia is not necessary The cancerous tissue is destroyed by the slow process of thermo-electrocoagulation avoiding all sparking and the coagulation is carried out well beyond the diseased area to the normal healthy tissue to insure complete destruction of the growth

The same procedure as detailed above is carried out with regard to the inguinal glands Preoperative and postoperative roentgen ray therapy is advised

Pfahler and Widman report a series of cases which were treated by radiotherapy and electrocoagulation. Certain cases respond better when

physician who neglects this dark field examination or if not possessing the facilities to carry out this procedure, fails to direct the patient to where it can be done is guilty of moral malpractice, at least.

If dark field examinations be negative for three or four successive days, and if the Wassermann reaction be negative, local treatment may be applied It is wise to continue weekly serologic examinations until the sixth week or the secondary period has been passed

Many chancroids can be cured by correcting the hygienic habits of the patient, as uncleanliness is usually the forerunner There are many remedies offered for cure such as application of caustics and acids but the writer has found that crystals of argyrol are very efficient and where this is unsuccessful or by reason of the phagedenic spread, the method recommended by Robbins and Seabury is applied

The chancroid is cleansed and a 10 to 20 per cent solution of cocaine is applied directly with a swab which is held in place several minutes A liberal application of 25 per cent cupric sulphate is made to the excavated area, and with the monopolar current of the diathermy apparatus and the vacuum electrode, the ulcer is completely fulgurated, care being given to carry the destruction well under the undermined edges and beyond.

Corbus has pointed out that using a fine needle as an electrode and desiccating the sore rather than sparking it, is superior as it does not carbonize the tissues and at the same time permits greater heat penetration. The grayish-green area is now covered with a dusting powder and if there should be any spread, the procedure may be repeated. Usually in a few days the phagedenic ulcer has been changed to normal, healthy granulation tissue.

The accompanying unilateral inguinal adenitis may be treated with diathermy if seen before suppuration occurs. The smaller electrode is placed over the inflamed gland and the larger one beneath the buttocks and treatment given for 40 minutes repeated daily Should suppuration occur incision and enucleation of the gland are indicated.

Epithelioma

The etiology of cancer of the penis is unknown but it has been recognized that a long and adherent foreskin, with resultant irritation from smegma and a chronic balanoposthitis, predisposes Epithelioma among the circumcised is rare.

This condition arises on the glans or prepuce, frequently on the site of an old scar formation Keyes reports it may start as an indurated nodule under the skin or as a patch of leukoplakia. Beginning as a wart on the skin or an ulcer it becomes deeply ulcerated with granulating or cauliflower-like growths with a foul seropurulent discharge. It may spread and involve the entire penis and adjacent structures. It is slow growing and pain is usually not an early symptom. The regional lymph nodes are reported as becoming involved rather late,

during fever or who develop influenza or acute febrile conditions Santos in his experiments reported that 43° C (109 4 F) for 76 minutes 44° C (111 2 F) for 54 minutes and 45 C (113 F) for 37 minutes were necessary to kill gonococci It has been shown by others recently that *in vitro* the gonococcus will survive 30 minutes at 45 C (113° F) The point is whether experimental studies of the gonococcus grown *in vitro* help us determine their relative resistance in the tissues It may be analogous that despite recent research to discover a chemical gonococcicide the urologist frequently returns to the old established irrigant—potassium permanganate—notwithstanding the fact that its germicidal properties are much less than many others It would seem therefore that if by applying diathermy we create an unfavorable condition for the viability of the gonococcus without disturbing the mucosa we are accomplishing enough to warrant its trial.

Nagelschmidt with reference to the male urethra, states Theoretically it would be easy to apply heat deeply with diathermy but practically it is quite different. In order to obtain an even deep heat, one must apply diathermy with low amperage during a long time It is technically very difficult to diathermatize the whole urethra far into the bladder without heating up some places too high. In the pars pendula no difficulties appear As soon as we reach the root of the penis it is impossible without special technic to heat through the urethra in all directions with an even temperature Corbus and O Conor in their book state It is a firm belief that ultimately the technical difficulties which so far have prevented the absolute perfection of this method will be solved

The use of medical diathermy in the treatment of acute gonorrhea has been upheld by many authors—Roucayrol Seres Walker Watson, Canovas Cumberbatch and Robinson Corbus and O Conor Gomez and Gastano H. Schmidt Nagelschmidt, Shohan MacArthur Redewill and others—but has been discounted by recent textbooks of urology notably those of Keyes Pelouze and Eberhart in this country and MacDonagh of England

It is not within the scope of this chapter to discuss the physical principles which govern the development and application of the type of current suitable for diathermy It is sufficient to state that should this method be employed it is essential to get a good machine which will deliver all that is expected of it with a margin to spare It should be capable of delivering 2000 to 3000 ma. in a steady volume without appreciable variation over a period of one hour Small machines incapable of doing this do not produce results Whether a portable machine is desirable is a personal decision We like a portable machine because it can be moved from one room to another or even to the patient s home MacArthur in a personal communication informs me that he has a large machine with connections such that two patients can be treated at the same time Of the greatest importance are the

radium is applied together with roentgen ray therapy Amputation was carried out by electrocoagulation at approximately the junction of proximal and middle third, without regard for the urethra. There is no record of stricture formation and in a personal communication I am told there was none. While the method of amputation with electrocautery produces a bloodless field most surgeons would regard the abandoning of the new urinary meatus to its fate as hazardous

Gonorrheal Urethritis

Electrotherapy with the production of heat in the tissues in the treatment of gonorrhea is by no means new yet the evaluation of this method has not been firmly established This may be due to the misleading and colorful statements of enthusiasts or to the doleful negative confirmation of the doubters There is no specific cure for gonorrhea and, as diathermy is the production of electrical heat, it is useless to expect results other than those derived from heat actively generated in the tissues. It is a biologic finding that under all conditions heat up to the optimum point increases the activity of tissue cells, and down to a minimum point decreases the activity of the tissue cells which leads to the conclusion that the production of heat in the body tissues increases cell activity and thus the inflammatory reactions to an irritant are greatly accelerated

Medical diathermy has been regarded as having marked analgesic properties It increases cell activity and hyperemia, with its resulting slowing of the blood stream due to the dilatation of the blood vessel walls It increases diapedesis both in rate and amount, and accelerates phagocytosis It produces a deleterious effect directly upon the invading irritant and decreases the amount of scar tissue formation as the first changes in inflammation are accelerated and also reabsorption takes place faster

The contraindications to diathermy are few but must be understood It cannot be substituted for surgical drainage in a collection of pus—as diathermy may aggravate the condition and septicemia results It should never be used where there has been any hemorrhage or where there is possibility of any

The gonococcus has long presented cultural difficulties making it next to impossible to obtain growths except under the most favorable conditions as the pus obtained at epididymotomy Recently with the introduction of the calf brain media and attention to hydrogen-ion concentration it is reported the organisms may be cultured from the urethral pus It would seem that conditions have to be most favorable for its growth, and as the gonococcus is not very hardy the least unfavorable circumstances will have a tendency to destroy it. It has been a well-established fact that excess heat has a deleterious effect upon the gonococcus. The clinical course of acute gonorrhea has been markedly lessened in those individuals who have complications pro-

and thus surgical diathermy or fulguration is apt to occur with a resulting traumatic fistula.

Following the suggestion of MacArthur, the writer applies diathermy to the anterior urethra using two strips of block tin ½ inch wide, cut to a length which will run the entire urethra, anointed with K Y lubricating jelly and strapped with adhesive Attention is given to directing that the electrode on the floor of the penis be slightly smaller as the urethra is closer to the floor Intimate contact of all electrodes is most essential and it is best to have all cords completely insulated to the very point of attachment A small rubber cuff can be slipped over this point after the connection has been made It is

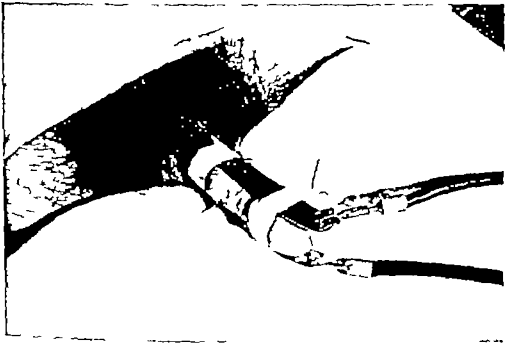

FIG. 1—Strip tin electrodes cut to length along the anterior urethra, held in place by adhesive Rubber cuffs may be pulled over connection points to prevent shock. (After MacArthur)

desirable to increase the current slowly taking at least five minutes before maximum intensity is produced and reverse the procedure for cutting off the current As there is no thermometer to act as an indicator the milliamperemeter must be watched with the current varying between 300 and 800 ma. The length of the treatment should be at least 1 hour and should be repeated daily or better twice daily until the gonococci are eradicated The temperature of the urethra can be raised to 109 to 112 F (42 78 to 44.44° C) for the duration of the treatment, a temperature at which it is alleged the gonococcus is destroyed This treatment can be continued for some time (Fig 1)

electrodes, which will be discussed under each condition because it is here the personal element enters

Provision has to be made so that the patient can lie for an hour or more without being disturbed and, if not under personal supervision the entire time at least watched by someone competent to judge if the patient is getting what is desired Better results are obtained by arousing the interest and coöperation of the patient, by explaining carefully to him exactly what you wish to accomplish and assuring him that there will be no shocks or painful effects After the first application with no untoward effects, the patient's morale is raised, particularly with clinical improvement, and afterward the cord connecting with the switch is given him so he can break the circuit if the heat becomes too intense.

It would seem that diathermy will never become popular, at best, mainly from economic reasons The physician needs special expensive apparatus a separate room for an hour or more, and the procedure must have skilful supervision. Of necessity a larger fee must be charged to the patient, who in these times of economic stress is more than likely unable to pay it Thus it will be shelved except for the wealthy, or in those distinct cases where diathermy is so superior to other forms of treatment that self-preservation of professional rank will impel its use.

To the patient presenting himself with acute gonorrheal urethritis in the early stage, i e., the first or second day, with the infection limited to the anterior urethra, anterior to penoscrotal juncture, diathermy may aid in effecting a speedy cure By the two-glass test, the first may be cloudy and contain a few shreds but the second should be clear Theoretically this is the time, if diathermy is able to sterilize the urethra by killing the gonococci the best results should be obtained comparable to a successful so-called abortive treatment, which is seldom employed The great difficulty has been to get a suitable set of electrodes which will give even heat to the urethra. Various types of intra urethral electrodes have been devised notably the one by Corbus, which is unsuccessful because

1 A basic urologic maxim states that no instrument should be passed in the inflamed urethra in the presence of gonococci.

2 Patient is usually not able to tolerate instrument in the inflamed urethra for sufficient period of time to get desired result. Corbus states however 'Contrary to the general impression of this form of treatment it is painless during the period of application After the withdrawal of the thermophore there is a copious discharge of serum and mucus which lasts until the next urination. The writer does not favor this treatment

3 As the urethra is not of uniform caliber an electrode does not fit snugly against the mucosa, so that sparking will occur

4 Heat is liable to be concentrated on the tip of the instrument,

has not been so favorable whether because of faulty technic or because we failed to get proper coöperation from our patients In most cases the discharge appeared a little more profuse after the first treatment and then gradually cleared The acute symptoms were alleviated Gonococci did not seem to disappear any more quickly than with other methods Clinic patients are difficult to hold to treatment, particularly when the symptoms with which they present themselves have abated. It has been observed that, as our technic improved better results were obtained and we are inclined to blame ourselves rather than the method for our earlier failures We do not advocate this as a routine treatment for acute urethritis

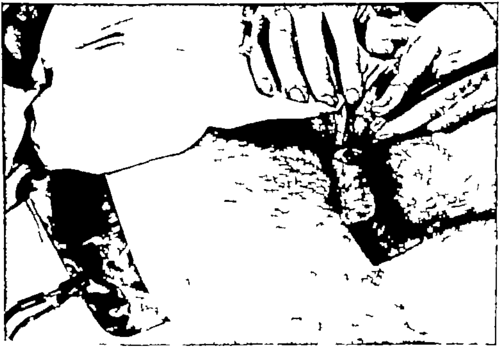

FIG. 3—Localized inflammation in perineum—Cowper's gland. Small block tin electrode over affected area and held in place by adhesive after shaving. Large electrode (6 by 8 in.) beneath buttocks.

With posterior involvement of the urethra which occurs in the majority of cases treated by any means complications may occur and it is here that diathermy occupies first rank in the treatment. Prophylactic treatments to the posterior urethra and prostate have been advised at this time where there has been a period of inactivity with older methods.

Periurethritis may occur anywhere along the urethra but the commonest sites are immediately posterior to the glans penis and in the perineum. The latter may be due to extension from the glands of Littré or from inflammation in Cowper's glands

This treatment does allay all the acute symptoms and checks the discharge considerably, even if the infection has invaded the bulbous portion of the urethra, and can be used in conjunction with the various accepted modes of treatment, as internal medication hand injections or irrigations, copious draughts of water, free catharsis, restriction of exercise and diet, and a taboo to sexual excitement and alcohol

In the acute fulminating types where the penis is edematous, the tips of the meatus and the prepuce are swollen and the patient complains of intense dysuria, palliative treatment alone can be instituted, as injections or irrigations are not indicated or tolerated and dia

FIG. 3—Molded block tin electrodes held in place by adhesive straps in periurethritis. Larger electrode on top—smaller on bottom. Rubber cuffs may be pulled over connection to avoid shock.

thermy occupies a stellar rôle and acts as an excellent palliative measure as often one treatment will entirely relieve the acute symptoms and injections can be resumed shortly

Redewill *et al* in a recent article maintain that with properly applied electrodes external to the penis the urethra having been previously filled with 0 5 to 1 per cent mercurochrome, uniformly excellent results can be obtained with the use of diathermy

MacArthur reports a series of 15 cases of acute gonorrheal urethritis in which, after the fifth diathermy treatment, the gonococcus could not be found in 14. In two cases a recurrence was noted.

Our experience with diathermy in the treatment of acute gonorrhea

A patient with acute prostatitis is a hospital case because the effectiveness of the treatment directed to the prostate in the first few hours will determine the future management It is here that a portable diathermy machine is indicated for it can be brought to the patient s bed The patient is placed on his belly with the larger so-called inactive electrode of block tin approximately 6 by 8 inches anointed with soap lather or K Y lubricating jelly beneath the lower abdomen. The buttocks are spread with one hand and the prostatic electrode copiously anointed with lubricant, is introduced easily and carefully into the rectum, directing the concave metal portion to come in actual contact with the diseased portion of the prostate as having been previously determined by rectal palpation This may be turned to various areas during the treatment if necessary Too much emphasis cannot be placed upon how skilfully and painlessly the introduction of this electrode should be carried out. The patient is particularly apprehensive at the beginning of the first treatment, the prostate may be exceedingly tender and there may be some tenesmus with attempt to force the electrode out but the effectiveness of the treatment depends upon how accurately the electrode is placed so the electrical heat may be generated at the point desired. Upon not being shocked nor hurt, but on the contrary experiencing the soothing effects the patient s morale is raised and the second treatment will go more easily with better coöperation The thermometer is introduced through the shaft of the electrode which may be held in place with small sand bags above and below it, which also help to steady it.

The current is increased gradually taking at least five minutes to arrive at a maximum temperature of 110 F or 43 33 C Above this temperature the patient complains of tenesmus and sacral pain although the maximum temperature reached has been 112 F (44.44 C) The temperature registered in the thermometer is 1½ degrees less than that generated in the tissues Even when the patient is tolerant of a high temperature it is difficult to obtain as the blood seems to carry the heat away faster after a temperature of 109 to 110 F is reached. The milliamperemeter may vary from 1000 to 1800 Many patients may not be able to tolerate this temperature at first, but most will be able to bear it if it is gradually attained In some however the tolerance will not be that high and in these the patients statements must be given as much weight as the thermometer in the prostatic electrode

The treatment should extend over a period of 40 minutes to 1 hour or longer daily or even twice a day until the acute symptoms disappear

Catheterization may have to be carried out for retention of urine and should be done under the strictest aseptic conditions using a catheter which will cause the least amount of trauma, even a woven

While this may present itself as marked periurethral infiltration, a large percentage undergo suppuration with the formation of an abscess with persistent urethral fistula, or a persistence of the gonococcus in the follicles causes recurrence of the acute urethritis Diathermy is very useful in checking the inflammation and preventing abscess formation, and if a persistent urethral fistula be present with demonstrable organisms in eradicating the gonococci and aiding in a speedy closure of the fistula with abatement of the urethritis. Should an abscess form, diathermy is contraindicated and surgical drainage instituted.

If the inflammation is confined to the penile urethra, two small tin electrodes are employed, with the smaller one which should be just of sufficient size to cover the affected area placed on the posterior surface the larger electrode directly opposite on the anterior surface, and both strapped in place with adhesive. Usually not more than 200 to 300 ma. are required, which is repeated daily for at least an hour (Figs. 2 3)

In cases of periurethritis involving the perineum, an electrode is fitted over the inflamed area on the perineum and the block tin plate is used as the other electrode, employing not more than 800 to 1200 ma of current.

We have observed diathermy clear up these troublesome peri urethral fistulas where older methods were of no avail If pus forms, it must be drained surgically

Acute Prostatitis

Diathermy is the treatment of choice in the management of acute prostatitis occurring either as a complication of an acute urethritis or in that smaller group of cases where the infection is hematogenous from disease elsewhere—as influenza. It far surpasses the old time-honored methods of applying heat—namely sitz baths and hot rectal douches—because the heat can be actively directed to the prostate with a higher temperature, which is more uniform and over a longer length of time It relieves the patient quickly of the distressing symptoms including retention of urine, if that be present and reduces the size of the prostate rapidly and thereby shortens the duration of the disease. Outside of a slight tenesmus which may be present at the introduction of the prostatic electrode at the first treatment and which usually disappears afterward it has a distinct soothing effect upon the patient. In accordance with accepted general surgical principles, if pus collects forming an abscess prostatotomy is demanded. The older method of passing a sound through the urethra and rupturing the abscess with the hope that it will drain into the urethra is not looked upon with favor but open operation with drainage established to keep from rupture into bladder or rectum

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olivary tipped or steel catheter if necessary, with plenty of lubrication All other local forms of treatment should be stopped during an acute prostatitis The same routine is carried out in an acute infection of the seminal vesicles

Diathermy has produced remarkable results in our cases of acute prostatitis and when presenting themselves early enough for palliative treatment to be instituted, prostatic abscess is a rare termination. Often for patients with acute prostatitis refusing to be hospitalized, and in institutions where diathermy cannot be carried out for one reason or another hot rectal douches or hot sitz baths are advised several times daily

Chronic Prostatitis

Chronic prostatitis may result as a termination of an acute prostatitis or it may be the product of the insidious extension occurring in the majority of cases with an acute urethritis It may or may not produce any symptoms but with absorption it acts as a focus for a host of symptoms which will not be relieved until a careful search reveals the prostate as an offending portal.

The time-honored routine treatment of chronic prostatitis with digital massage and total bladder irrigation supplemented with sounds overdilatation of the posterior urethra, bacterin and protein therapy has not produced brilliant results either in a permanent cure or the rapidity with which it was accomplished Indeed in a minority of patients who present themselves with a chronic prostatitis it may be impossible to get the gland in such a shape that the microscopic examination of the prostatic drop does not reveal pus even though the symptoms may be entirely gone When a patient asks at the beginning in what time he may expect a cure the truthful answer of impossible to state rarely satisfies and yet anywhere from ' two months to two years with the average of approximately eleven months is even less gratifying.

Anything which tends to offer a better solution of this inaccessible infection is welcome and diathermy has been offered as a means of shortening the duration of chronic prostatitis. It is carried out in the same manner as described under Acute Prostatitis the treatment being given two or three times a week. Less distress is experienced upon the introduction of the electrode and the tenesmus is practically absent. At least 40-minute treatments should be given (Fig 4)

The diagnosis of chronic prostatitis is made, first upon the findings at rectal palpation of the prostate and secondly, on the immediate examination under high power microscopic field (⅙ objective) of the expressed secretions with the white blood cell count of not more than 5 per field being regarded as normal This examination is carried out of co se before any treatment is instituted but Mac Arthur advises t a check up" is not necessary between treatments

which should be given in series In fact, he states that patients who have been given prostatic massage before their diathermy treatment do not respond as well as those who had none A patient should be given one or two series of eight or ten treatments each and then a "check-up" on the prostatic secretion and if this be abnormal, the series repeated

MacArthur reports very good results from diathermy in chronic prostatitis Our results like many others are variable being not nearly as striking as in the cases of acute prostatitis In a few diathermy produced a cure the cell count dropping to normal and staying there

Fig. 4—Diathermy in chronic prostatitis Block tin electrode (6 by 8 in.) beneath abdomen. Thermometer in shaft of prostatic electrode registers ½ degrees less than is generated in prostate. Prostatic electrode may be held firmly in place by sandbags.

after repeated examinations at lengthening intervals but in a majority there has been no apparent beneficial result It is true that the symptoms are relieved but in other respects the condition is similar to that in the cases treated by digital massage in other words, discouraging Perhaps in our series of cases the treatments were not prolonged enough, and many of them had received previous prostatic massage It was noted that careful attention to technical details gives better results Again the economic conditions come up most patients will not give the time necessary and have not the means to have diathermy carried out neither do we have the physical accommodations demanded in treating all patients with chronic prostatitis with diathermy

especially in hospital clinics Therefore we reserve diathermy for those selected cases in which either by time, examination or economic con dition it seems indicated.

Epididymitis

Epididymitis a complication in about 15 to 20 per cent of cases of acute urethritis, with greater prevalence in hospital clinic cases is included in the group of circumscribed areas of inflammation which are amenable to diathermy The usual palliative treatment is rest in bed with elevation by a bandage or strapping application of heat or cold, free catharsis, forcing fluids and perhaps protein injections. Local treatment must be stopped. This usually incapacitates the patient for from five to fourteen days, with the possibility that if the condition does not subside incision and drainage may be necessitated. *Some urologists do not believe in the palliative treatment but recommend* immediate drainage which results in a shorter hospital stay We advocate palliative treatment except in the following conditions, which indicate that an epididymotomy should be done

1 In the relief of pain
2 Cases which do not subside promptly under palliative treatment.
3 Recurrent attacks
4 Bilateral cases.
5 As a greater chance against sterility on the affected side
6 To enable the patient to get on his feet sooner

Diathermy has been recommended as a means of relieving the subjective symptoms and speedily returning the epididymis to normal. We have discarded the scrotal thermophore in favor of two block tin electrodes cut to size and molded to fit the conditions as described by MacArthur As the epididymis lies under the posterior surface of the scrotum, the posterior electrode overlying this should be smaller than the anterior one. The electrodes are covered with soap lather or lubricating jelly and may be strapped with adhesive to hold them in place held by the patient or supported by small sandbags (Fig 5) The pressure applied on the upper electrode holds the lower electrode in place. The tolerance to heat varies greatly in patients. As there is no thermometer connection the heat should be raised gradually using from 750 to 800 ma and the treatment carried on for at least 40 minutes to 1 hour after maximum temperature has been reached At times it may be well to increase the heat until cutaneous discomfort is noticed and then reduce the current slightly so no unpleasant sensation accompanies the treatment. Treatments for a shorter time do not get the desired results and should be given daily until the condition improves

MacArthur reports a series of 35 cases of epididymitis, 21 of which

were hospital patients In these the average number of days before pain had subsided was 1 76 and the number of diathermy treatments required to reduce pain was 1 57 The average stay in the hospital was 6 52 days The patients were not discharged until all the pain and tenderness had subsided as had the swelling These patients were all in condition to begin local treatment. Average number of diathermy treatments was 3.28 There were 14 cases in his private office the length of time to relieve pain was 20 days and the number of treatments was 1 9 Entire condition subsided in 6 7 days with the average number of diathermy treatments being 6 1

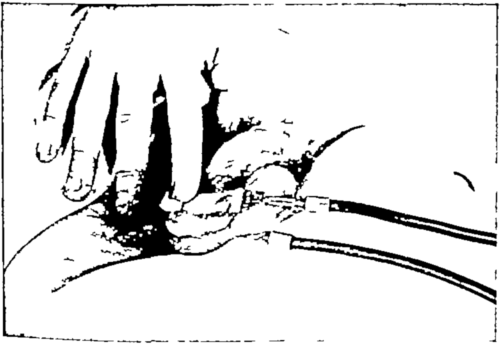

Fig. 5—Molded block tin electrodes in acute epididymitis. Smaller electrode on posterior surface and larger on anterio May be held in place by light sandbag having patient hold it. Pressure on anterior electrode keeps posterio electrode in place

In 10 of the office cases posterior irrigations were begun 9.8 days after onset of the epididymitis accompanied by prostatic diathermy without recurrences In this series of 35 cases none required operative interference In 6 cases the patients were able to carry on with their work after the first diathermy treatment although one had a recurrence on the third day which forced him to lay off for a day

Our results are by no means comparable to this and, may be recorded as indifferent. It is our experience that in a majority of cases the pain usually subsides as soon as the patient stays in bed with elevation of the epididymis The diathermy treatment probably aided

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1 The local condition the urethritis may be treated in the usual way or by diathermy, which will not produce results if a posterior involvement has occurred in which case treatment may be directed to the prostate

2 To the sterilization of the blood stream and what results may be accomplished by chemotherapy

3 To the joint

Here diathermy produces marked beneficial results, as the heat may be accurately generated Various types of electrodes may be used but the technic must be accurate to obtain results The wire mesh electrodes have been advocated because they conform better to the irregularity of the joint. Where block tin molded electrodes are used attention has to be given if the heat is required through the joint that the electrodes are of equal size but where it is required that the heat be nearer one surface of a joint, the smaller electrode should be placed over that area and kept in place by strapping and sandbags.

The method of a cuff arrangement above and below the joint does not work out well the current going almost through the superficial tissues. The various types of molded to-fit block tin electrodes adapt themselves very well.

The treatments should be from 40 minutes to 1 hour daily until the patient is better and the amount of current varies with the individual ranging from 800 to 2000 ma. The tolerance of the patient is the best guide

Chronic Inflammation of Sheath of Corpora Cavernosa

Chronic inflammation of the erectile tissues of the penis especially of the corpora cavernosa, leads to areas of induration which, although painless progress so that erection is difficult and impossible or accomplished with a marked curvation of the penis The condition may progress until these fibrous plaques become calcareous. The etiology is unknown but is often associated with a rheumatic or gouty diathesis The majority of these patients have a chronic prostatitis also

The treatment has been most unsatisfactory with attention to any correction in metabolism prostatic massage internal administration of potassium iodide and often direct injections of fibrolysin with the condition often becoming progressively worse.

We have tried diathermy in several of these cases along with other mentioned treatment and the results have been as good with other methods if not better If the fibrous plaques are formed as a result of chronic inflammation then in diathermy we have the best means of combating this if seen early enough. The electrodes of molded block tin are applied in the same manner as for periurethral conditions and lasting 40 minutes the treatments are given two or three times a

us in getting relief, but in accomplishing the rapid reduction of swelling and getting the patient out of the hospital in six days we cannot record anything like the remarkable results as reported by MacArthur It has been our belief that it is unwise to resume local treatment under a month in cases of epididymitis treated palliatively but where epididymotomy has been performed, local treatment can be started sooner We advise all cases of epididymitis to stay in bed, preferably in the hospital where they can be watched and where it is possible to carry out diathermy as an adjunct to the routine treatment of elevation forcing fluids and possibly nonspecific protein therapy

A distressing funiculitis often accompanies the involvement of the epididymis and this may be treated by placing one electrode over the globus minor of the epididymis while the other is placed over the external abdominal ring This permits heat to extend over the accessible portion of the vas and should be carried out as previously described.

The question arises naturally whether in those cases treated with diathermy, the testicular function of spermatogenesis is disturbed MacArthur, attempting to answer this was not definitely able to state at the time of his report but is of the opinion that it is not There were 10 cases of epididymitis which were given from one to ten treatments of diathermy after which operation was performed and a section of testis removed In 6 of the 10 cases the pathologic findings in the testes were so severe that spermatogenesis was lost, but this could readily be due to the intensity of the infection and not to the diathermy In 2 of 10 cases (one of four treatments and one of six) both had active spermatogenesis. In a case of chronic bilateral epididymitis in which it was either a case of doing a bilateral epididymectomy or treating with diathermy, the treatments were given to both epididymes after which all the pain and swelling subsided One month later semen showed actively motile sperms and this was checked up in another similar case and motile sperms found. The consensus of opinion is that there is no permanent damage

Diathermy should be withheld and epididymotomy employed when actual pus formation is present.

Arthritis

The acute arthritis which occurs as a metastatic complication of acute gonorrheal urethritis is a serious affair and demands prompt and efficient remedial measures else the individual may be crippled for life While nearly any joint may be affected the larger joints as the knee ankle hip and elbow are mostly involved and it may be polyarticular Synovitis and tenosynovitis may accompany it.

The treatment should be directed to three main issues

to disturbances of micturition mostly frequency and perhaps some pain at the end of urination. The urine is usually clear and free from pus The experienced cystoscopist will have no difficulty in diagnosis and the polyps are quickly and easily destroyed by electrocoagulation. A large block tin electrode 6 by 8 inches is placed beneath the patient s buttocks then with a No 6 French Bugbee electrode in the cystoscope the tip is placed in contact with the base of the polyp and with a low current it is quickly destroyed Much better vision and manipulation may be obtained by having a continuous stream of boric solution flowing to distend the urethra. The current should not be too strong not nearly as much as is used in destroying tumors of the bladder as the posterior urethra is more sensitive and the patient does not tolerate this as well. We usually employ local anesthesia only which is obtained by placing a tablet consisting of one grain of novocaine in the posterior urethra with a tablet depositor which is especially designed for that purpose If the patient is nervous and apprehensive a hypodermic injection of morphine and atropine is given one-half hour before the operation or some other sedative like sodium amytal may be used Caudal anesthesia has been used and where the occasion demands it general anesthesia where due caution must be taken in regard to electric sparks and ether if used

Usually such growths can be destroyed at one sitting and the patient is advised to return in several weeks for observation.

The same treatment is applicable and the response equally as good in similar diseases of the posterior urethra as tumors of the verumontanum hypertrophy of the verumontanum and granulation tissue in the posterior urethra We have used this bipolar method of electrocoagulation in cases of varices or bleeding coming from the posterior urethra, in some instances following topical application of silver nitrate when nothing else would control the marked hemorrhage with continuous dilatation of the urethra, the bleeding point is sought, and placing the tip of the Bugbee electrode on it electrocoagulation is accomplished with a low current.

The interest of urologists has been revived recently in the handling of patients suffering from what has been called a median bar which may be either fibrous or glandular The bladder neck may become sclerosed and contracted by fibrous scar tissue and this may be termed *fibrous obstruction* and may follow prostatectomy The first work and attempt at correction was done by Guthrie just one hundred years ago and it was stated by him that only those bars or obstructions which were not associated with glandular enlargement were amenable to the instrumentation he devised before the days of direct vision of these contractures This method fell into disuse and remained dormant until Young brought forth his punch with which pieces were bitten out of the bladder neck at various angles until the obstruction was removed The great danger in this procedure was hemorrhage and it has been our custom to do a suprapubic cystotomy and bite out

week. As this disease is slowly progressive it may be some time before definite signs indicate that even this treatment is of no avail.

Enuresis

Enuresis in children is essentially a functional disease with a natural tendency toward cessation at puberty Often a careful physical exam ination in male children will disclose some alteration in the urine, irritation about the meatus or glans stricture calculus or spina bifida occulta the correction of which will arrest this condition Curtailing the fluid intake after 4 P.M and the placing of a large wooden pill box or wooden spool in the lumbar region with a string that may be tied around the waist which will shift the child when an attempt is made to sleep on the back are often sufficient to effect a cessation of the enuresis Of the remaining cases, we have found by a cystoscopic examination, mostly under a general anesthetic, that the prostatic urethra is usually markedly congested with an enlargement and engorgement of the verumontanum With the tip of the No 6 French Bugbee electrode placed on the verumontanum through the cystoscope and a large electrode beneath the buttocks the bipolar current is turned on and the verumontanum electrocoagulated

We have seen a number of young boys where this treatment was highly effective, enuresis not being resumed after a single treatment.

Urethra

There are several conditions involving the urethra, particularly the posterior urethra, in which electrosurgery produces brilliant results that in the past have been difficult to accomplish with the older methods of sounds overdilatation of the posterior urethra and the topical applications with silver nitrate

The general practitioner is usually not equipped nor has he the ability to make cystoscopic examinations, but he should bear in mind that patients complaining of some disturbance of micturition such as frequency or burning or possibly terminal hematuria, may have some pathologic change in the posterior urethra, which will account for this even though the cystoscopic examination fails to reveal any abnormal ity in the bladder or kidneys The expert makes it a part of the routine examination after completing the inspection of the bladder thoroughly to investigate the urethra. This is best carried out with the cysto-urethroscope or convex sheath and having a continuous stream of boric solution flowing all the time to distend the urethra. This makes a better instrument for diagnostic purposes at least than the ordi nary urethroscope with either the curved posterior tube or straight tube and permits a thorough inspection of the entire urethra.

At times small polyps or polypoid formations are found at the vesical neck or just outside in the prostatic urethra, which give rise

Collings has always emphasized that this electrical excision is only applicable in fibrous bars and he does not recommend its use in the glandular type The knife-like electrode is introduced through the modified McCarthy foroblique panendoscope and the excision carried out under direct vision which is aided by continuous irrigations throughout the operation

The patient should be hospitalized and the operation carried out under caudal anesthesia or as we have ascertained in the last few cases local anesthesia the drug being given directly into the bar by a long needle attachment to the hypodermic syringe A large block tin electrode is placed under the buttocks for an inactive electrode

The author states The cysto-urethroscope is passed into the bladder With the bladder partially distended and the inflow and outflow of water regulated the electrode is engaged upon the bar at 6 o clock The current is turned on and marked bubbling is noted The protein molecules are exploded by jostling of the high frequency oscillations The urethroscope and electrode are slowly pulled back *en masse* until the verumontanum appears A white furrow about 2 mm. deep is seen The instrument with the electrode in the furrow is then pushed forward and through the bladder neck Working back and forth in this manner the groove is gradually widened and deepened Cut until you see the last obstructing fibrous band has been sawed into One can from the verumontanum look down a deep valley (perhaps 1 5 cm deep) and see the base of the bladder Persist in your efforts until you are satisfied the patient has a wide open bladder neck If this is accomplished the patient will be relieved We were all timid at first and cut too little Do not be afraid of the rectum—it is still 1 5 cm away (as determined on the cadaver)

By turning the knife blade sideways one engages the blade on the bladder neck at 5 o clock. Cut downward and backward until the intervening tissue is whittled away This procedure is repeated at 7 o clock

"The operation can be slowly and precisely performed in about 20 minutes

"There is only a minimal amount of heat penetration beyond the line of incision By microscopic examination we have found tissue destruction extends only 1 to 2 mm. beyond the cut

The one drawback to this procedure has been the necessity of an apparatus to deliver the cutting current The ordinary diathermy or high-frequency machine will not deliver this current. We now employ in our clinic the same Westinghouse machine as used in the modified Caulk punch operation For the visual excision of fibrous bars this instrument is effective but it is not suitable for the glandular types of obstruction neither is it as rapid nor has it as much latitude as the modified Caulk which formerly carried this out without direct vision.

Stern conceived the idea of a loop excisor and in 1926 started a movement which has been termed variously as *transurethral prostatic*

the pieces under direct vision, so the hemorrhage, if there were any, could be controlled at that time

Recently some new instruments have been offered for the correction of this obstruction some of which employ direct vision, and from being relegated to a palliative procedure, a wild enthusiasm has swept along to such an extent that not only are the fibrotic median bars attacked but resection of glandular hypertrophy, so that in a large urban hospital no radical prostatectomy has been carried out during the past year

Formerly, this method was advised in those obstructions of the vesical neck due to a fibrous median bar formation where the glandular element was not the primary factor, in contractions of the neck following prostatectomy as a palliative procedure in those cases which for one reason or another could not stand a radical operation and where enough tissue could be removed to prevent retention and lastly in cases of carcinoma of the prostate for the relief of retention with no expectation of a curative process.

Caulk has devised an ingenious punch to correct obstructions at the bladder neck The instrument is an electrical adaptation of the Young punch and, while observation of the portion to be excised may be carried out prior to the excision, the actual punching is carried out without visual aid Recently there has been added a visual system to this punch. The patient should be hospitalized The anesthesia may be caudal or local, employing the long needle attachment to the syringe, and the operation may be carried out painlessly with the exception of the point when the tissue is just being completely excised. A large block tin plate is placed beneath the buttocks for the inactive electrode. The author states that the heat generated does not destroy this removed tissue and a histopathologic section may be made where diagnosis is desired. He has further stated recently that not only are the fibrous contractures at the bladder neck amenable to this operation but he is employing it in the glandular types of obstruction, namely hypertrophy, cutting sections at various angles to relieve the obstruction, following which there was noticed a recession in the size of the gland

Birdsall has modified the Caulk punch by enlarging the fenestra and employing a cutting current as delivered by the portable endotherm a spark gap machine of the Westinghouse Company which combines medical and surgical diathermy with a cutting current. The hemorrhage is minimal and a Robinson catheter No 24 French is tied in for forty-eight hours. There are some patients whose urethra will not take this No 28 French instrument general contraindications will be discussed later

Collings has offered a method of electrical excision of these bars by utilizing the cutting current. The oscillations of the cutting current are some fourteen or fifteen times faster per second than the fulgurating high frequency suggested by Beer and require a special apparatus.

only factors to be considered in the end results even if the remainder of the gland undergoes retrogressive changes

Bladder

With the introduction of the high frequency current presented to urology by Dr Edwin Beer in 1910 the treatment of benign tumors of the bladder was completely revised The poor results following open operation were so discouraging that the profession welcomed this new electrosurgical procedure and today it is the accepted mode of treatment. It is essential that the correct diagnosis be made and the expert cystoscopist is able in well over 90 per cent of cases to differentiate between a noninfiltrating benign tumor and an infiltrating malignant tumor Failure to respond to electrocoagulation is suggestive that *the growth is malignant.*

Beer advised the monopolar current but the bipolar current is used mostly now A large 6 by 8 inch block tin electrode is placed beneath the patient s buttocks to act as an inactive electrode. The cystoscope with the Bugbee electrode is passed into the bladder and the tip of the electrode is placed at the base of the narrow pedicle and the papilloma destroyed. Where the base cannot be seen the electrode is placed against this projecting mass but the tumor is destroyed more quickly when the base can be attacked. When the current which may be used stronger here than in the posterior urethra is turned on a stream of bubbles arises and pieces of tissue may seem to burst. The speed of destruction depends upon the size of the tumor but most papillomas can be destroyed in several sittings As there is a marked tendency to recurrence approximately 40 per cent, the patient is requested to report at three months intervals for the first year six months intervals the second year and yearly thereafter to check up against recurrence.

When the tumor discovered in the bladder is considered malignant, the question of the form of treatment is most important, first, in that the prognosis depends upon how early and accurately the diagnosis is made, and secondly as there is no universally accepted treatment and each case is a study in itself the procedure employed being dependent on many factors.

There is no accepted pathologic classification of bladder tumors and the cystoscopist should rely upon the clinical classification of malignancy The expert cystoscopist is able to give a better opinion than anyone else, notwithstanding that biopsy has been advised in doubtful cases despite the warning that this may disseminate the growth faster Papillomas are considered potentially malignant and are liable to undergo malignant degeneration if not destroyed The cystoscopist divides the malignant tumors into two types—noninfiltrating and infiltrating

Upon the family physician rests the responsibility of early diagnosis

resection and *punch prostatectomy* Davis proved the practicability of loop resection by reporting in 1931 a series of 100 cases with no fatalities Marked improvement had been made in the machines producing the cutting current and in the switching devices to the coagulation current for the arrest of hemorrhage. McCarthy, alive to its possibilities proceeded along scientific lines to produce a unit nearer to perfection Enlisting engineering aid the "McCarthy surgical unit" has been offered as the last word in the tube-set high frequency machine The controversy has not been definitely settled as to whether the tube-set or a spark-gap machine is the better type It is claimed that the tube-set has many advantages over the spark-gap and none of its disadvantages, due to its uniformly continuous oscillation, which makes cutting smoother From the practical standpoint in our clinic, the cutting and coagulation current, as produced from a portable spark gap endotherm, is very effective.

A special bakelite sheath is provided for the panendoscope, and the resection carried out under direct vision Multiple bites are necessary, and usually the first bite is the largest The patient should have a permanent catheter for several days

The same careful examination and preparation are as necessary for these patients as for those who are candidates for a radical operation where renal and cardiovascular tests besides others have to reach a certain standard before the patient qualifies Most of the instruments used for resection are of fairly large caliber (No 28 French) certain urethras tolerate such manipulation poorly and urethral fever results as after any other instrumentation this should be carefully guarded against, as well as ascending infection We have seen several cases of stricture formation follow particularly near the meatus. While the procedure has been described as bloodless, it may be far from this at times With new improvements in switching from the cutting to the coagulating current, much hemorrhage is controlled with the coagulating electrode and this should be carried out after each bite is removed

It takes considerable manipulative skill to become a resectionist, even if one is more than fairly familiar with the cystoscope and it has been discarded by some after several disastrous attempts We have had and seen certain cases where radical operation had to be carried out where attempts at resection had failed for one reason or another

Not every prostatic enlargement is suitable for resection, and cases carefully selected will give the best results Certain it is that those prostatics with intravesical complications such as stone tumor or diverticulum are not suitable candidates Very large intravesical and large intra-urethral enlargements are difficult to handle and often impossible.

Sufficient time has not elapsed for ultimate evaluation of this procedure for recovery and relieving of residual urine are not the

generally regarded as hopeless In certain clinics the papillary car cinomas are destroyed by cystoscopic electrocoagulation and radium is applied by a cystoscopic carrier with results comparable to other means. Again radium has been applied in all cases of noninfiltrating and infiltrating growths, and results comparable with surgery have been obtained in the earlier cases attacking those advanced cases where surgery is contraindicated it has relieved the patient of symptoms and extended the duration of life

Surgical diathermy has been advised for carcinoma of the prostate attacking by the perineal and also suprapubic routes but has not found much favor The results of treatment of carcinoma of the prostate are even more discouraging than that of carcinoma of the bladder We used this method on one patient who died of a severe hemorrhage from the prostate three days after operation.

The best results in carcinoma of the prostate have been in those cases which were not suspicioned prior to operation nor suspected at operation but with the diagnosis made by histopathologic section after complete enucleation.

Those cases which are suspected at operation but where the gland has been completely removed and diagnosed definitely in the laboratory are next in line Postoperative roentgen ray therapy is advised Where the diagnosis is suspected prior to operation radical removal is not usually advised except by Young who recommends extracapsular prostatectomy if the gland has not broken over the capsule

Radium has been advised in these cases and may be applied in the form of seeds either by exposing the gland suprapubically and then perineally or by implanting through a needle in the perineum. The roentgen ray will disclose the exact position of these implanted seeds The histopathologic diagnosis may be made by aspirating some of the prostatic tissue through a special needle. Roentgenograms should be made of the bones and lungs to rule out metastasis before any treatment

The roentgen ray will often relieve the distressing pain in the back and legs which may be the first subjective symptom. The prognosis is bad.

Ureter

The treatment for stenosis of the ureteral orifice formerly was incision which was liable to be attended with severe bleeding and which in a few reported cases necessitated cystotomy This also applied to those cases where there was a distinct bulging of the last centimeter of the ureter due to the occlusion by a stone

The ureteral orifice can now be slit for any reason by surgical diathermy through the cystoscope With the patient prepared as for cystoscopic electrocoagulation a special electrode with a small Y-shaped tip is introduced into the orifice and with the bipolar current, the roof of the ureter is incised for a short distance. This may be accom

in these cases of malignant tumor of the bladder With the cardinal symptom of often painless hematuria, the patient consults his advisor, who too often complacently administers a urinary antiseptic and is readily satisfied if the hematuria ceases in a day or two Insistence of cystoscopic examination at this time would do more for the patient s prognosis than our most effective treatment later on

With a sessile type of tumor, the best information with regard to what extent infiltration has taken place is obtained by an aerocystogram and a cystogram which we employ routinely A roentgenologic examination should be made of the bones of the pelvis and spine and of the lungs for possible metastasis, which is late and rare in those carcinomas affecting the bladder only, but common in those cases associated with carcinoma of the prostate.

Leading authorities agree that the best results are obtained by radical surgery in those selected early cases where the tumor is favorably situated for excision with or without resection of the ureter Total cystectomy with transplantation of the ureters has a high mortality except in the hands of the most expert

In those cases which are either too extensive for resection or unfavorably situated but yet not too far advanced and without visible evidence of metastasis we advise a combination of a suprapubic cystotomy and destruction of the tumor by diathermy General anesthesia is employed, and an inactive electrode 6 by 8 inches is placed under the sacrum. The active electrode is selected from several sizes of flat disks and screwed on the handle and the strong current is controlled by a foot switch Due precaution must be taken if ether is used as an anesthetic on account of the sparking by the machine. After cystotomy the active electrode is introduced directly on the tumor and it is destroyed by electrocoagulation The charred tissue may be removed by a curet and the destruction is carried out wide of the tumor tissue Little attention is paid to the ureteral orifices and usually there is no retention on the involved side In a series of cases treated in this manner a few years ago we implanted radium in the destroyed base but the results were no better than in those who did not receive radium so we discontinued it. Roentgen ray therapy should precede and follow this procedure This combination of surgery and diathermy is not designed primarily to be curative, but it will relieve patients of distressing symptoms improve their condition in some cases allow them to return to their occupation and add a few years to their life We have a few cases where the diagnosis was confirmed by histopathologic section that are living and well five to eight years after operation

In those advanced cases any treatment other than palliative has a tendency to hasten their end so we usually resort to roentgen-ray therapy and cystotomy when retention occurs

The so-called papillary carcinoma or noninfiltrating type responds better to treatment than the infiltrating type in fact, the latter is

did not commence until they had exposed themselves to sunlight, following which healing was rapid

In the bilateral cases surgery is usually contraindicated and heliotherapy has been advised Diathermy has been advocated for palliative purposes but mostly frowned upon. In some cases there is a persistent and distressing cystitis which resists all palliative measures Beer states that fulguration of these ulcerations and granulations does produce temporary relief and reapplications of the current may be necessary

Genital tuberculosis primary in the epididymis and going on to suppuration is amenable to surgery and epididymectomy is indicated There is a marked tendency to become bilateral It should be borne in mind that the infection in the epididymis may be secondary to that in the kidney and the kidneys ruled out before any surgical procedure is carried out. Diathermy is contraindicated Tuberculin given therapeutically in the form of bacillus emulsion has proved beneficial in cases where focal local and general reaction has been avoided

Testicle

Following the suggestion of Ewing who stated in 1911 that all tumors of the testicle should be regarded as teratomas or mixed tumors we advise radical surgery as soon as diagnosis is made. Mostly in young adults in the third decade the condition is highly malignant and the prognosis bad with metastasis occurring mostly to retroperitoneal lymph nodes within a year whether or not a radical resection of the lymph nodes up to the lumbar group is carried out. The Memorial Hospital of New York City reports encouraging results with the application of radium but these have not been found elsewhere.

panied with the Bugbee electrode if one is expert Slitting of the lower vesical portion of the ureter will often permit the prompt passage of stones, which have been lodged at this narrowest portion of the ureter

Medical diathermy has been recommended for patients with stones in the ureter or kidney but it is not much used As heat often relieves these conditions, diathermy should be more efficacious but in our experience those patients with a ureteral colic require morphine hypodermically and will tolerate nothing during the attack of severe pain.

Kidney

We have had little experience with diathermy in renal conditions, but it has been advocated in all those cases where heat was formerly employed. As the kidney is closer to the posterior surface the smaller electrode, 4 inches square, is placed over the kidney region and the larger 10 by 8 inches, is placed on the upper abdomen. The current is increased gradually with the amperage averaging 1000 to 2000 This should be over a period of 40 minutes.

In tumors of the kidney diathermy is contraindicated. Early diagnosis as made by chromo-ureteroscopy pyeloscopy, retrograde or intravenous urography indicates surgery with preoperative and post operative roentgen-ray therapy In those larger hypernephromas which are regarded as inoperable roentgen ray therapy has a marked tendency to relieve pain stop hematuria and produce a marked diminution in the size of the tumor

Roentgen ray therapy is indicated also in the mixed tumors of the kidney seen in children and where removal cannot be accomplished.

Genito-urinary Tuberculosis

Long clinical experience has placed genito-urinary tuberculosis with the primary seat in the kidney upon a surgical basis. Always secondary to tuberculosis elsewhere, it is spoken of as primary in the particular region of the genito-urinary tract that it affects first, usually the kidney and epididymis While theoretically tuberculosis may begin as a bilateral affair it clinically develops as a unilateral affair and when diagnosis of surgical kidney is made nephrectomy should be carried out. In certain selected bilateral cases when one kidney is only slightly impaired and its fellow more so the better kidney has improved after nephrectomy of the worse one.

As the condition is systemic, the patient is by no means cured after nephrectomy There is a marked tendency to breaking down of the wound A general antituberculosis régime is advocated—rest, good food and fresh air Under the last head heliotherapy carefully carried out has a distinct place and it has been reported by Bumpus that some patients volunteered the information that healing of the wound

CHAPTER TWENTY TWO

PHYSICAL AGENTS IN TREATMENT OF GYNECOLOGIC CONDITIONS

GRANT E WARD M.D F.A.C.S

SECTION I

DIATHERMY

History.—The employment of high frequency currents for medical or surgical purposes has come to us through a long process of development, brought about by the untiring gratuitous coöperative labors of a group of physicists and medical and surgical investigators to all of whom a debt of deep gratitude is due As one reviews the history it becomes evident that advances were often simultaneous and quite independent in widely separated areas making it difficult at times to assign priority in the construction of apparatus and improvements in technic. Elsewhere the history and physics of high frequency currents and their biophysical effects are given in greater detail than is possible or necessary here suffice it to define a few terms for clarity

Definitions.—Diathermy in the simplest and most exact sense, means to heat through. From the word alone no electrical connection is evident, but since its incipiency, diathermy has been used to designate that form of heat produced within the living tissues by the passage of a high frequency current through them when this heat is not destructive but within physiologic limits Within the last few years radio-tube apparatus have been devised for diathermy treatments which create an electromagnetic field between two large plates so that when the patient is placed within this field a rise in general body temperature to 105 or 106 F results.

Electrosurgery, on the other hand is the utilization of properly regulated high-frequency electric currents in the performance of surgical operations as in making incisions in normal tissue, excising diseased areas or in the desiccation (dehydration) or coagulation destruction The therapeutic agent is the electrically developed lethal heat within the tissues themselves in contradistinction to the physiologic heat of diathermy

Endothermy is a name coined many years ago but not emphasized or enlarged upon until the notable work of George A Wyeth in 1924 Some authorities claim for Germany the origin of this word

Obviously with strong currents higher temperatures are generated a happy balance between voltage and amperage must be obtained to generate the proper amount of heat without shocking and pain As the application is prolonged the temperature rises to a point where the conduction and radiation disperse the heat as rapidly as it is formed and a state of equilibrium exists the given current maintaining the same temperature as a rule and any increase in the current strength increasing the heat proportionally

Such conditions prevail in a homogeneous medium but in the body certain variations occur due to the different densities of the body tissues through which the currents pass The denser tissues offer increased resistance allowing less current to flow through with correspondingly less temperature rise Tissues vary in density from greatest to least as follows bone cartilage ligaments fascia skin muscle and fat. Heat is also dispersed by radiation and by conduction of the blood stream

High frequency currents are known to travel on the surface of metal conductors That this also holds in the case of organic substances was shown by Bettman and Crohn who worked with bologna sausage observing that the highest temperature registered at the periphery just beneath the skin of the sausage This then brings about a difference of opinion from the theoretic aspect described above From a practical standpoint, however investigation reveals increases in deep temperatures during the application of high frequency currents dependent on the strength of current and balance between voltage and amperage In other words in spite of the variations in tissue structures and densities temperatures in deeper organs as the lungs liver and pelvic organs are moderately raised by diathermy currents the depth of this temperature and its exact location being determined by the size shape and location of the electrodes Bettman and Crohn further demonstrated that when agar agar is the homogeneous conducting medium, temperatures occurred midway between equal-sized electrodes or nearer the smaller of two electrodes of different area. If a piece of bone or other nonconducting substance is placed in the center of the agar the electromagnetic waves are bent around the bone, and a concentration of current with a greater rise in temperature appears at the periphery of the bone. E A Weinberg and the author (unpublished) have confirmed these observations in living dogs by inserting a clinical thermometer in a hole bored in the bone of the foreleg and another in the surrounding soft parts while diathermy was applied higher temperature readings being obtained in the soft parts next to the bone.

Diseases.—In discussing the use of diathermy in gynecology the writer will refer freely to the work of Corbus and O Conor and Thomas H Cherry and others (see bibliography) In spite of some theoretic and laboratory evidence to the contrary heat penetration is

others, that Mr Kurt Stoye, a physicist was the first to utilize it. Endothermy literally means 'heat from within.' Wyeth calls electrodesiccation 'monoterminal endothermy', electrocoagulation 'biterminal endothermy and the cutting current ' endotherm knife. Further differentiation of electrodesiccation, electrocoagulation and cutting is given under "electrosurgery

The term "uniterminal refers to one cable connection between the small active electrode and the instrument the patient acting as a con denser, disseminating the current, which then returns to the generator ' Biterminal" infers two direct connections between patient and apparatus (1) a small active electrode concentrating the current to raise the local temperature within physiologic limits (diathermy) *or above that lethal to the tissues (electrosurgery)*, and (2) a large, inactive or plate electrode in close contact with the patient s skin at a point distant from the treated area Frequently two equal electrodes are employed to raise uniformly the temperature of a part of the body or extremity In medical literature the words bipolar' and "monopolar' were extensively used, but as there is no polarity to a high-frequency current such terms are erroneous.

Physiology.—The physiology of heat is thoroughly discussed in Volume I Diathermy heat is because of its mode of production much more penetrating than that from any other source As high frequency currents pass through the tissues, heat develops within them differ ing in this way from the radiation and conduction heat of hot instru ments applied to the surface of the body, as hot water bottles hot baths, the Paquelin or electric cautery etc. Painstaking clinical and laboratory researches have proved that this heat penetrates to practi cally any depth of the body and raises the temperature of deep-seated organs. Therapeutic temperatures of 108° F can be obtained in the urethra and rectum, and 111 F in the cervix With this eleva tion there is *pari passu* an increase in the oral temperature from 0 5 to 1 0 degree. Such temperatures produce the familiar physiologic effects of dilatation of blood vessels and increased circulation and have sedative effects upon the nerve endings and relaxation of the muscles. These effects bring the body defense mechanisms leukocytosis and swelling of the tissues with exudation of blood plasma, to fight disease or promote repair processes Certain authors claim a most im portant function to be the germicidal action upon invading organisms, particularly the gonococcus noted for its susceptibility to moderately high temperatures but more recent investigations disprove this assumption The above facts place diathermy among the standard treat ments of gynecologic diseases.

The degree of heat applied is under the direct control of the opera tor being varied by (1) size of the electrodes (2) densities of the tissues treated (3) amount of current utilized and (4) duration of application

and relief of pain from reduction of pressure upon nerve filaments Likewise in turn a rapid absorption of the exudate follows the increased blood flow together with mobilization of the body's natural defense resources Since the inflamed adnexa usually prolapse into the culdesac of Douglas Cherry performed a series of experiments to ascertain temperature rises here With an abdominal electrode measuring 18 by 12 5 cm and a vaginal electrode the exposed surface of which measured 5 by 3 cm., the temperature of the culdesac was elevated to 48 C while the vaginal temperature registered 44 C For this treatment a special electrode (Fig 1) is made with a hole drilled near the surface for the exposure of the thermometer bulb to the vaginal tissues Through this contrivance by adding two degrees to the temperature registered in the vaginal tissues he estimated the approximate degree of heat in the adnexa and with such a technic treated a series of 100 cases with disease of the tubes or ovaries or both

In spite of the fact that electrotherapists and authorities on physiotherapy have continually warned against using diathermy in pus-containing cavities with no outlet for drainage it seems reasonable to Cherry to assume that if gonococci were the exciting factor producing such a condition and if a penetration of the diseased structure by a heat of 46 C could be obtained the causal agent would be destroyed with incidental reduction in the inflammation. Such specific heat effects are questioned by Scheffey and others Improvement by this reduction in infection and the active hyperemia was realized in a large percentage of Cherry's 100 cases Diagnosis was made either by obtaining positive smears from the urethra and cervix in most of the patients or in others with negative smears by numerous pus cells and a history of subacute or chronic urethritis endocervicitis skenitis or bartholinitis The degrees of pelvic involvement varied from small thickened tender adnexa to large pus tubes or tubo-ovarian abscesses entirely filling the pelvis Twenty three of the patients had adnexal disease without masses and 77 had adnexal disease with masses.

The results in this series of cases are so remarkable that a few figures are of interest In all there was practically instant relief of pain. The masses disappeared entirely in 18 of the 77 and were reduced in size in 14 more a total improvement of 32 or 41 5 per cent. The complete disappearance of the inflammatory tumor seemed more apt to occur where there was an initial attack of adnexal infection while in the chronic ones the reduction in size and subsidence of the acute symptoms made the lesions practically innocuous although remaining palpable requiring more prolonged diathermy Forty nine of the 77 were entirely relieved of symptoms operations being unnecessary or refused the other 28 were operated on At operation the masses were found to be hyperemic soft edematous and smooth and the adhesions vascular and thin in contradistinction to the thickened fibrous type so frequently encountered in chronic pelvic in

regulated by varying the size and shape of electrodes and their points of application In this manner, therapeutic temperatures are applied to the urethra vagina cervix and even the adnexa when they are the seat of salpingitis or tubo-ovarian abscesses The amount of heat tolerated by the normal tissue without destruction or coagulation, probably varies between 55 and 58° C Cherry applied diathermy through the abdomen of a dog heating the bladder and rectum to 52° C without histopathologic changes He also developed 55° C in the human cervix for 10 minutes without any gross tissue changes

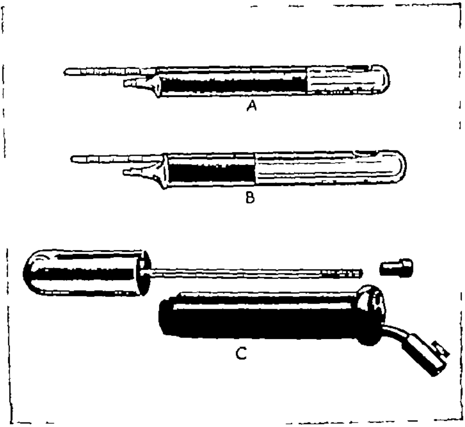

FIG. 1—Cherry's vaginal electrodes. Active metal surface comes in contact with cervical and vaginal tissues. An open window connects with a canal which passes through upper surface of electrode its entire length. This allows introduction of thermometer with bulb in contact with vaginal tissues, giving accurate measurements of heat dosage. A, electrode used in the treatment of cervix and adnexa. B electrode with larger active surface fo application to urethra, utilized at same treatment for cervix and adnexa. C, Cherry's recently improved model.

It is well known that living tissue dies at 60 C temperature also lethal to the gonococcus which is vulnerable to as low a temperature as 42 C for ten minutes.

Diathermy treatment of pelvic infections causes hyperemia and quickened circulat on with reduction in stasis in the engorged vessels

and relief of pain from reduction of pressure upon nerve filaments Likewise in turn, a rapid absorption of the exudate follows the increased blood flow together with mobilization of the body s natural defense resources Since the inflamed adnexa usually prolapse into the culdesac of Douglas Cherry performed a series of experiments to ascertain temperature rises here. With an abdominal electrode measuring 18 by 12 5 cm and a vaginal electrode the exposed surface of which measured 5 by 3 cm. the temperature of the culdesac was elevated to 48 C. while the vaginal temperature registered 44 C For this treatment a special electrode (Fig 1) is made with a hole drilled near the surface for the exposure of the thermometer bulb to the vaginal tissues Through this contrivance by adding two degrees to the temperature registered in the vaginal tissues he estimated the approximate degree of heat in the adnexa and with such a technic, treated a series of 100 cases with disease of the tubes or ovaries or both.

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flammatory disease. Consequently, operation was greatly facilitated the tumors being readily delivered with a minimum of trauma to surrounding structures. The contents had been reduced by the treatment to a thin, watery, straw-colored fluid instead of the usual thick, creamy, purulent exudate and all cultures were negative. The lessened operative trauma made convalescence free from discomfort and pain, vomiting and distention Only two wound infections occurred—7 7 per cent as against 30 per cent wound infection in a large series that

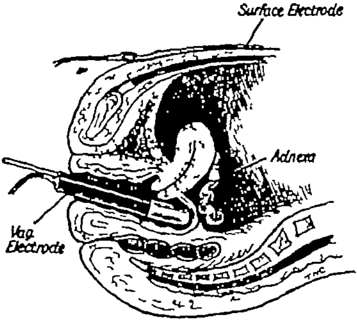

Fig. 2.—Application of Cherry's vaginal electrode A for cervical and adnexal infection.

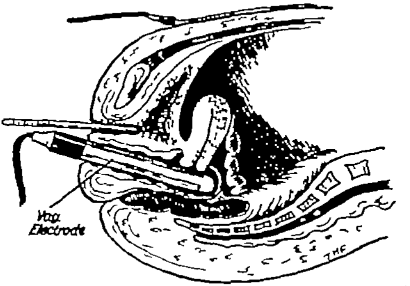

Fig 3—Cherry's ele ode B in place for treatment of urethra, cervix and adnexa.

had no preoperative diathermy treatment. In summary Cherry says "I would venture the assertion that diathermy is probably the most satisfactory available agent for the conservative treatment of pelvic *infections due to the gonococcus It relieves pain diminishes the pelvic* masses and aids in complete resolution Used as a preoperative therapeutic measure it will eliminate many of the technical difficulties in the removal of large pelvic masses and thereby contributes a smoother convalescence Incidentally the percentage of postoperative wound infections is lessened." Further investigation and verification of these results should be carried out in our larger clinics

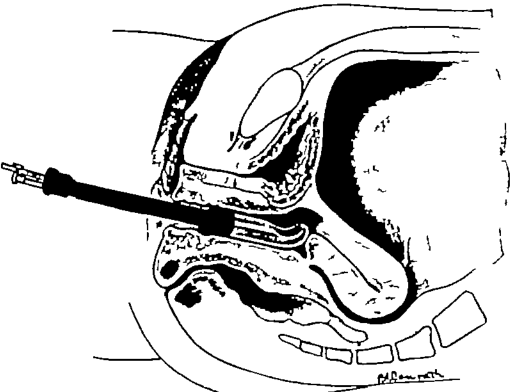

Fig. 4—Chapman electrode in place treating cervix and adnexa. (Courtesy of Journal of Radiology)

There are data at present insufficient to state whether pelvic infections other than those of gonococcal origin such as follow parturition or abortion will yield so readily to diathermy The little available evidence seems to point in the adverse direction The streptococcus staphylococcus or colon bacillus requires a temperature of 58 to 60 C for destruction Diathermy through the pelvis raises the temperature insufficiently to have any specific effect on these bacteria and on the contrary seems to aggravate the symptoms The degrees of heat developed produce a suitable cultural temperature in which these

bacteria thrive pelvic peritonitis and other complications following, the diagnosis of the organism is therefore extremely important.

Technic of Diathermy Application in the Pelvis—The pelvic application of diathermy is carried out in one of several ways (1) Two large equal electrodes are placed one on the abdomen and one on the sacrum with a consequent temperature increase midway between the electrodes. Inasmuch as the temperature is to be concentrated as near as possible in the culdesac and around the cervix, the abdominovaginal application is more practical (2) Several special electrodes have been devised for application to the cervix and the vaginal vault,

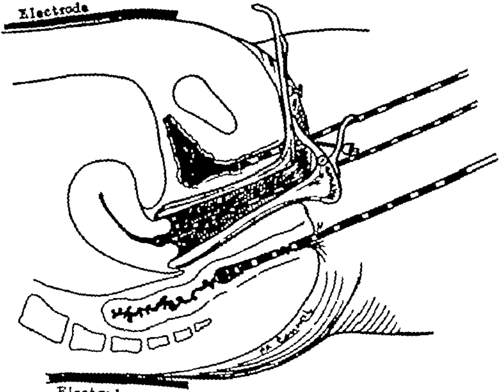

Fig 5—R blee lectrode No —a bivalve Graves speculum placed in an upside-down position, the handle acting as a binding post for connection of the electric terminal. Therm meters in urethra, rectum and cervix, measuring temperatures of 108 to 109 F (4 2 to 4 78 C) in rectum and vagina and 102 5 to 103 F (39.16 to 39.44 C.)

this being the nearest approach to the prolapsed diseased adnexa in the culdesac (3) Another method is the abdominorectal application giving less favorable results The accompanying illustrations (Figs. 2 to 8) show better than description the methods of applying the electrodes In the treatment of gonorrheal urethritis the Corbus electrode (Fig 9) is applied through the urethra with a pad on the abdomen or beneath the sacrum

In the abdominovaginal or abdomino-urethral application a thermometer is contained in the active electrode as a guide to the temperature rise Accurate approximation of the electrodes both on the surface and in the cavity treated is important. The large pad electrode, usually consisting of block tin is covered with green soap for accurate contact and held firmly on the abdomen by belt or sand bag —not necessary for sacral application as then the patient lies on the electrode, assuring even contact with the skin. Any irregularities on

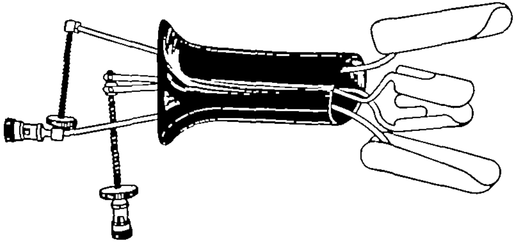

FIG. 6—Roblee electrode No with four overlapping blades. This electrode is placed in vagina as a hollow cylinder and then dilated to bring two blades forceful contact against the cervi and the other two against vaginal walls, the longest posterio blade pressing well back into culdesac. When used with the lumbosacral or belt electrode temperatures of 09 to 1 0 F (42 78 to 43 33 C) were recorded for urethra and rectum and 103 to 04 F (39 44 t 40 C) for the cervix.

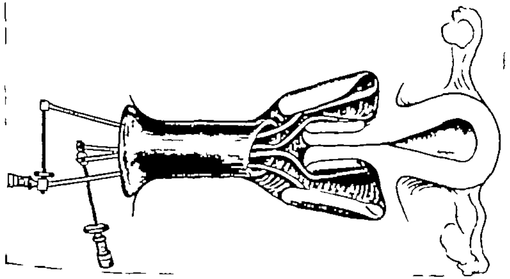

FIG. 7—Roblee electrode No. 2 in place

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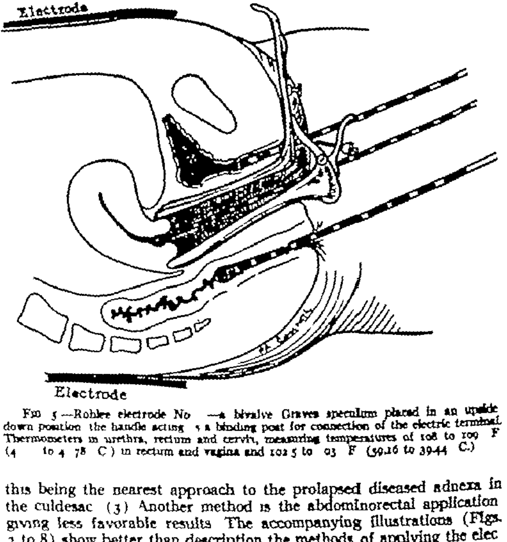

FIG 5 —Roblee electrode No —a bivalve Graves speculum placed in an upside down position the handle acting as a binding post for connection of the electric terminal Thermometers in urethra, rectum and cervix, measuring temperatures of 108 to 109 F (4 to 4 78 C) in rectum and vagina and 102 5 to 03 F (39.16 to 39.44 C.)

this being the nearest approach to the prolapsed diseased adnexa in the culdesac (3) Another method is the abdominorectal application giving less favorable results The accompanying illustrations (Figs. 2 to 8) show better than description the methods of applying the electrodes In the treatment of gonorrheal urethritis the Corbus electrode (Fig 9) is applied through the urethra with a pad on the abdomen or beneath the sacrum

the temperature rises above this the current is reduced to maintain the desired degree of heat The treatment is continued for from 15 to 30 minutes and repeated at three to five day intervals until improvement becomes stationary Endocervicitis usually coexistent with the adnexal disease receives treatment while the pelvis is diathermized. After the intrapelvic disease has cleared up any lingering chronic infection requires electrocoagulation to be described in a subsequent paragraph

Diathermy for acute gonorrheal urethritis is not firmly established but should be mentioned because of beneficial results in certain cases. Treatment is by the use of the Corbus thermophore (Fig 9) a small round instrument with a tapering metal tip an inch and a half to two inches in length carrying a thermometer in its center Application is directly within the urethra, with a large inactive pad beneath the buttocks. The urethral orifice is cleansed with boric solution and the sterilized thermophore inserted and held in place by a suitable clamp fastened to the table Treatment is continued for from 15 to 30 minutes at a temperature of 41° C (800 to 1 000 ma of current) and repeated in from three to five days until urethral discharge has subsided. The current is increased slowly taking about eight minutes to reach the desired milliamperage and temperature.

The destruction of infection in Skene s glands requires a true surgical procedure but is discussed here because of its close association with gonorrheal infections of the other pelvic organs The periurethral tissues are cleansed with a mild antiseptic and 2 per cent novocaine injected at four points about the urethra A needle-like electrode carrying either a fairly strong uniterminal current of rather high amperage or a moderately strong biterminal current, is inserted the full length of the gland until a whitish coagulated area appears about the needle This insures complete destruction of the infection and the epithelial lining of the gland. Argyrol 10 per cent is applied to the urethra about twice a week until healing occurs in two to three weeks

The literature contains many reports of the use of diathermy in the treatment of *dysmenorrhea* with highly satisfactory results the increased blood flow accounting for the improvement It is also stated that *amenorrhea* when due to hypoplasia of the endometrium is greatly benefited by the dilatation of blood vessels (Theilhaber) Guthmann I de Ruben and others vouch for the symptomatic improvement in *vesical affections* particularly cystitis Here the muscular spasm is relieved and painful urination or incontinence eliminated

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the surface cause uneven concentration of the current with uncomfortable sparking or, in some, a burn. The electrodes are now connected to the machine and the current turned on, beginning around 200 to 250 ma. and slowly increasing until vaginal temperature reaches 42 or 43° C This usually requires 1,000 to 1 500 ma. of current. If

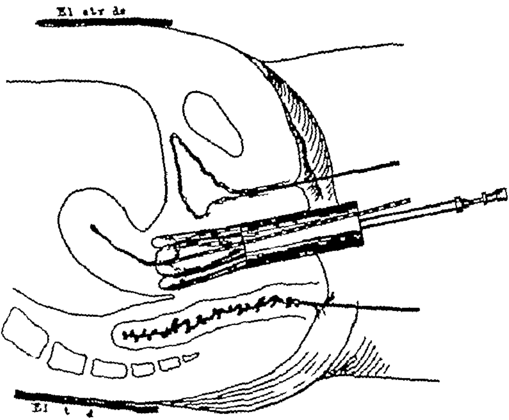

FIG 8.—Zener cervicovaginal electrode, No 1 with four blades closing about cervix, concentrating heat in cervical canal and immediate parametrium without material loss in rectum and urethra giving temperatures of [illegible]09 to [illegible]1 F (42.78 to 43.33 C.) in cervix and urethra and 108 to 109 F (42.22 to 4[illegible].78 C) in rectum.

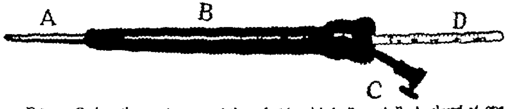

FIG 9.—Corbus thermophore consisting of thin nickel silver shell, A, closed at one end measuring 5 mm in diameter A hard rubber shield, B measures 15 cm. by 1 cm and allo[illegible] [illegible] of 4 cm f[illegible] insertion in the cervix or urethra. C, insulated terminal pro[illegible]ided for atta[illegible]hment of cable supplying current. D thermometer inserted to full depth [illegible] shell and [illegible]eadings taken from exposed portion. It has been found that great accuracy is necessary in constructing the instrument to insure its proper per[illegible]formance. Any [illegible]mall diathermy machine capable [illegible] supplying 800 to 1,000 ma. will produce heat [illegible]nough t[illegible] [illegible]pply the thermophore (Courtesy of Corbus and O'Conor and Bruc[illegible] Publishing C[illegible])

The first electrosurgical current was uniterminal—only one wire and one electrode connecting the patient with the generator This "fulguration" current is of high voltage (potential) from a long spark gap and correspondingly low amperage (volume of current) The effective heat penetration of such current is limited and soon its inefficiency for the destruction of any large amount of diseased tissue was realized During years of development the voltage has been reduced by shortening the spark gap and altering the transformer there being *pari passu* a perceptible increase in amperage Higher frequencies were obtained with the shorter spark gap and still higher frequencies with the introduction of a multiple gap (Clark) The present-day currents are much more powerful than the earlier ones destroying readily to a depth of 2 or 3 mm in a short time longer contact coagulating tissue to 1 5 cm. from the point of application when necessary Along with this development of such powerful currents came the advent of electrosurgical cutting first popularized by George A. Wyeth so useful in sealing capillaries and lymph vessels as the incision is made.

Electrodesiccation

Electrodesiccation as its name implies is the dehydration of tissues by the heat developed within them during the passage of a high frequency current. William L Clark of Philadelphia first to employ this term, uses it to designate that form of tissue-destruction caused by the passage of a uniterminal current of high amperage and low voltage (short spark gap) The cells are devoid of water (dehydrated) and appear elongated and shriveled under the microscope the cell outline however being still visible These changes are most marked in the heat-sensitive tumor cells

The author studied the histologic changes effected by electrosurgical currents in an effort to confirm Clark s work and found that by varying the strength (amperage and voltage) and time of application electrodesiccation could be obtained with either a uniterminal or biterminal current, much less time being required however for desiccation with the stronger biterminal current. In the literature however the term *desiccation* usually means the dehydration of tissues with a uniterminal current that is a current delivered to the patient through one electrode and one wire from the generator the patient dissipating the current through the air back to its source.

Electrocoagulation

Electrocoagulation was first employed by E Doyen of Paris about 1907 who enlarged upon the fulguration of Reviere Pozzi and de Keating Hart by changing the electrical connections to the patient and by using more powerful transformers. Two wires connect the generator to the patient one to a large pad beneath the back or but

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SECTION II

ELECTROSURGERY

The use of high frequency, oscillating electric currents as physical agents in performing any surgical operation is called 'electrosurgery' in contradistinction to the usual surgery with the cold sharp scalpel. Under diathermy' a careful differentiation between it and electrosurgery is made There are three electrosurgical currents, designated by their effects desiccation (dehydration), coagulation and cutting Electrosurgical currents are alternating in character i.e their direction of flow changes many times per second and because these alternations are so numerous usually 750 000 to 1 000 000 and at times 3 000,000 per second the term ***high frequency*** is used to distinguish the current from the low frequency commercial currents of ordinarily 60 cycles or 120 oscillations per second. The higher the oscillations, the smoother the current with less muscular response and more effective application. These currents are of varying voltage and amperage depending upon the needs.

homogeneous mass The tumor cells being more sensitive to heat are affected first, forming large masses of granular débris within a hyalinized stroma the stroma is more resistant to heat and slowly destroyed In the usual specimens the connective-tissue stroma is seen as a fused translucent eosin staining matrix of hyalinized material with partially destroyed nuclei scattered here and there The blood vessels contain clots adhering to the heat-damaged wall Coagulation may be obtained by a heavy uniterminal current of high amperage and applied for a considerable length of time as compared to that necessary for desiccation Usually however electrocoagulation is accomplished with a biterminal current generating high destructive temperatures the tissues actually boiling in their own juices This type of destruction is used for large tumors whereas desiccation is sufficient for small, benign and malignant ones

Electrosurgical Cutting

Electrosurgical cutting currents were first experimented with by Lee de Forest in 1908 and later by others but without practical application until the thoroughgoing studies of George A Wyeth who has so aptly popularized this important surgical adjuvant Tissues are easily and quickly *severed by currents of* higher frequency than that required for desiccation or coagulation for example 1 500 000 to 2,000,000 oscillations or more per second For the smoothest cutting the oscillations should be as nearly equal as possible notably those from radio tubes which are undamped that is of equally sustained oscillations without rest periods between them Currents from a spark gap generator are damped that is the oscillations are in chains each oscillation in the chain being consecutively shorter than the previous one until the zero line is reached with a rest period following allowing the current to pile up on each side of the gap until sufficiently powerful to jump it when oscillations again occur with similarly decreasing height (Desiccation and coagulation currents are usually of the damped variety) Primary union following electrosurgical cutting demands less penetration than for coagulation or desiccation and is obtained by lower voltage and higher frequency With a carefully balanced cutting current incisions are made with as little as one-tenth of a millimeter destruction of tissue at the skin edge (Ward using Wyeth s endotherm where radio tubes are source of current) By increasing the strength of the current any desired amount of penetration from this superficial effect up to that necessary to stop bleeding from small vessels is obtainable and with spark-gap generators on to flashing currents causing destruction to one or two millimeters on each side of the incision With such a current of course primary union is usually impossible these currents being for the removal of massive ulcerating malignancy where wound closure is im-

tocks and the other to the active, surgical electrode, which in his practice was a small disk. At present, most surgeons employ either a needle a flat blade with or without a sharp cutting edge, a blunt rod, a small ball, a wire loop or other form of small instrument, increasing the current density at the point of contact (Figs 10 11) Electrocoagulation as its name implies results from the actual heat coagulation of the tissue-protein, which appears under the microscope as a

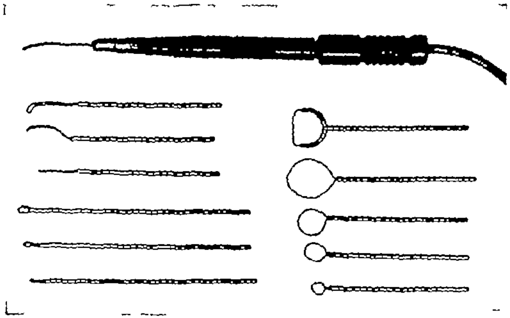

Fig. 10—Assortment of active electrodes curved, flat, diminutive knife blades, convenient in resecting tumors difficult of approach varying sizes of electrosurgical loops for scalloping out otherwise inaccessible tumors coagulating ball electrodes adjustable handle

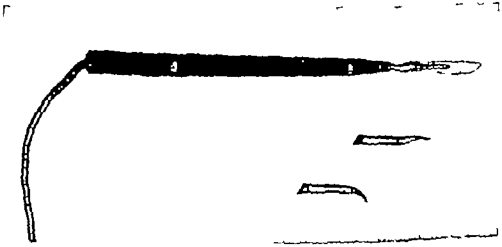

Fig —G E electrosurgical knife with interchangeable Bard-Parker blades

Robbins and Leabury describe the way to treat *chancroids* a 25 per cent solution of copper sulphate in distilled water is applied for a few minutes after which the lesion is desiccated well beyond the diseased margin A light antiseptic dressing is placed over the sore and in a few days the foul sloughing ulcer exhibits a healthy granulating surface.

Pruritus vulvae a most distressing and resistant disease calls for a thorough search of the general physical condition and study of the blood chemistry to exclude constitutional causes If none is found electrosurgery comes to the relief of the suffering patient. The current strength and the method of application depend entirely upon the extent and depth of the disease Superficial and less extensive involvement calls for the active point electrode carrying a uniterminal current to be played over the surface until white desiccation appears Moderately deep-seated diseases require that the needle touch or slightly penetrate the skin The duration of application may be shortened when desired by using a flat, disk like active electrode treating larger areas at a time This instrument is placed in direct contact with the skin until blanching occurs and then moved to an adjacent area. The after-care is a daily application of an antiseptic salve such as 1 per cent yellow oxide of mercury or mercurochrome, until the desiccated tissue comes away to be replaced by normal epithelium.

In the more extensive cases where the entire vulva and adjacent portions of the thigh or the perianal region are involved more radical procedures are necessary The cutting current is efficacious in excising the disease with a wide margin in normal tissue, the edges being brought together with suture for primary union when a fine current is used Stronger currents advisable when ulceration is present suggestive of malignancy prevent primary union the wounds healing by granulation The skin and subcutaneous fat are so redundant that contracture of large wounds is not disfiguring the edges being gradually pulled toward each other limiting the amount of cicatrix which is always soft following electrosurgery Occasionally after extensive operations, skin graft is necessary

Cysts of Bartholin's glands call for removal of the entire wall which prior to the advent of electrosurgery meant resection usually under a general anesthetic, and considerable hospitalization. Several years ago the author while treating a case of ranula, hit upon the idea of destroying the epithelial lining with a uniterminal current allowing the walls to fall together and heal by granulation Such a splendid result was obtained that cysts and epithelial lined cavities in other parts of the body have been successfully attacked in the same way Small Bartholin-gland cysts are treated under local anesthetic in the office larger ones usually require general anesthetic and short hospitalization. Whether the cyst be small or large the technic is the same (Fig 12) a strong cutting current opening the cyst and evacuating the contents The epithelial lining is then thoroughly destroyed by a strong desic

possible anyway The sterile, dry coagulum 1 to 2 mm. thick, prevents reimplantation or dissemination of cells

In electrosurgical cutting a tiny arc should be maintained between the electrode and the tissues, pressure obliterating this arc disseminates the current so rapidly that cutting is slow and with much destruction A new sense has to be learned by the surgeon—that of very delicate application of his electrode and rapid drawing of it over or through the tissues

Application of Electrosurgery

Vulva and Vagina.—*Small benign tumors* are promptly destroyed by a desiccating current under local anesthesia. The method of anesthesia is optional, and the needle electrode carrying a current of proper strength for the size of the tumor, is first played around the edges to cut off any dissemination of cells, should there be suspicion of early malignant change The rest of the tumor is then dehydrated curetted away with a small suitable curet and the base redesiccated to sufficient depth, destroying all cells which may be growing out into normal tissue

A method of indirect application is sometimes employed where the patient grasps a large tubular electrode or lies on an "inactive" pad. The operator then touches the diseased area with a needle the current passing through it and the operator, who acts as a condenser Heat is developed within the lesion where the current is concentrated as in the direct method, with the same destructive effect. The dehydrated tissue is then curetted away as before and the current reapplied if indicated

An antiseptic solution applied with a small cotton applicator insures against subsequent infection of this now sterile scab I prefer Scott's mercurochrome * Bohlman's gentian † or 7 per cent iodine.

For small lesions no dressing is necessary Larger or multiple ones require the usual surgical wound care during the healing period, which lasts from ten days to three weeks, depending upon the extent.

Sinclair Tousey describes painless removal of small skin tumors without anesthesia. Pedunculated ones are clamped at the base and the active electrode applied to the distal portion, the current (uniterminal or biterminal) only traversing the insensitive growth. If the growth is flat a curved pair of forceps (Tousey Baffle) is so placed that the tumor rests between its jaws the active electrode then being applied to the center With a biterminal current, the forceps completes the circuit through the operator who is, in turn connected to the machine if the current is uniterminal the forceps is grounded through the operator

* Scott's mercurochrome mercurochrome, 2 Gm. distilled water 35 cc. 95% alcohol, 55 cc. acetone 10 cc.

† Bohlman's gentian gentian violet, 2 Gm.; distilled water 35 cc. 95% alcohol, 55 cc. acetone, 10 cc.

cated with rapid healing where tissues are loose and freely movable A thorough application of radium should be given first then under general anesthesia the involved area removed with a wide margin of safety using the strongest cutting current and the base of the wound resterilized by coagulating to a depth of two or three millimeters eradicating all outgrowing cells and those spilled during the operation The coagulum is now painted with an antiseptic solution such as previously mentioned and the wound kept well protected with the proper dressings The sterile coagulum comes away in from one to two weeks allowing the development of rapidly growing granulations for epithelialization By combining these two therapeutic agents complete eradication of the disease is more certain and in addition electrosurgical removal counteracts the sclerosing action of the radium on the vessels permitting more rapid healing or earlier plastic repair and softer scars.

Urethra.—Electrosurgery furnishes a quick sure method of removal of the most painful urethral condition—*caruncle* Except in highly nervous patients the operation is performed under local anesthesia in the office A one or two per cent procaine solution injected on all sides blocks the urethra The smaller caruncles are simply desiccated down to the urethral wall and allowed to slough away larger ones are grasped with forceps and carefully resected with a fine cutting current Frequently, redundant urethral mucosa, likewise eradicated by electrosurgery, is mistaken for caruncle. The redundant mucosa is dissected away under local anesthesia or desiccated back to normal tissue. Corbus and O Conor describe a method of utilizing a narrow flat electrode placed consecutively in four radial positions destroying a small area of mucous membrane in each of the four quadrants of the urethral orifice As healing and shrinking take place the redundant mucosa is drawn into normal position

Urethral polyps usually small are readily removed under local anesthesia with a desiccating current, thoroughly dehydrating the polyp which sloughs away in a few days Should the polyp be large or malignant, its base can be cut through with a cutting current removing the tumor *en masse* and then the base coagulated

Following all of these urethral operations healing takes place in from ten days to two weeks the patient experiencing very little pain except in the exceptional case Local application of procaine or cocaine ointment will relieve all pain Usually however postoperative treatment is limited to ordinary cleansing measures

Cervix.—*Chronic endocervicitis* is the most common disease which confronts the gynecologist It is now recognized that the usual medical treatment of chemical antiseptics tampons etc. is only palliative except where the infection is superficial and has not penetrated to the base of the glands To cure the infection which over a long period of

cating or coagulating current, as the occasion demands, usually applied on a blunt or ball electrode complete and accurate penetration into every nook and crevice of the collapsed wall being imperative. The cavity is then painted with Bohlman s gentian, packed with iodoform gauze and dry dressings applied Daily application of the gentian and iodoform gauze is continued until the slough separates, the gentian then being discontinued, allowing healthy granulations to fill in and close the defect.

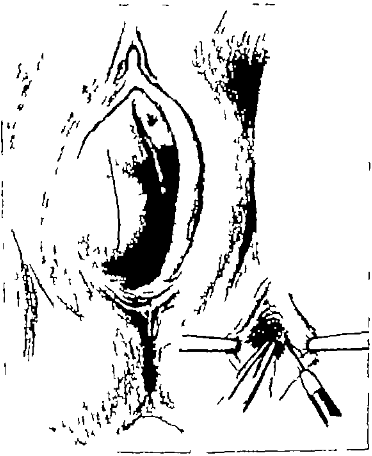

FIG 12—Electrosurgical incision of Bartholin's gland cyst Insert—Coagulation of epithelial lining.

In treating accessible *malignancy* such excellent results are obtained by radium therapy that it must always be considered. Many malignant tumors of the vulva and vagina are completely eradicated in the earlier stages by the thorough application of radium (See Sect. III) It is especially desirable in the treatment of vaginal malignancy, where exceptional improvement occurs surgical resection even with high-frequency currents being technically difficult and fraught with marked distortion Electrosurgical resection of tumors of the vulva is asso-

heals in another two or three weeks during which time inspection should be made once or twice and also within the next month or two to watch for any possible constriction of the canal Should any adhesions begin to develop they are readily broken up by the insertion of a small instrument or a cotton applicator

Mortimer N Hyams describes a clever method of conization of the cervix for destruction and removal of infected cervical tissue. After inserting the customary vaginal speculum with the patient in the dorsal position and cleaning out any residual leukorrhea, the cervical canal is anesthetized by placing a small crystal of cocaine in it An applicator saturated with 85 per cent cocaine solution is introduced and allowed to remain for five minutes and an inactive wet metal electrode strapped on the abdomen the patient being directed to make

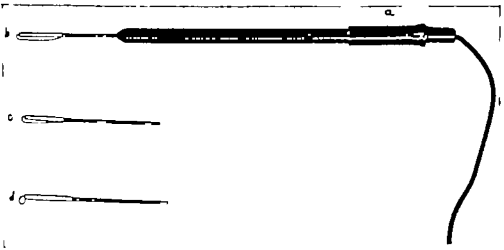

Fig. 3—Hyam's electrode fo conization of cervix.
(a) Swivel handle, allowing rotation f electrode without interference from attached wire.
(b and c) Porcelain tips with various sizes f wire arcs.
(d) Loop for removing bits f infected tissue high up in canal.

firm compression on the pad with hands assuring accurate contact and distracting her attention from the operator The active electrode (Fig 13) is a fine tungsten wire stretched over a silicon tube one and one-half inches long and properly attached at each end for the conduction of the current. The silicon tube and tungsten wire are held in a long suitable handle having a swivel joint for attachment of the cord from the generator The tungsten wire describes an arc of about one-eighth inch at its widest portion conforming to the normal contour of the cervical canal which is fusiform or spindle shaped Several sizes of electrodes are available with varying widths of the arc as well as others for biopsy and destruction in difficult angles of the

time has burrowed deeply into the racemose glands, forming large cysts full of pus and has extended high up to the internal os no method of treatment short of some form of surgery is sufficient to eradicate thoroughly the disease in its deepest hiding places Various scalpel operations have been devised which leave the cervix free of disease but subsequent labors are complicated by the reduced cervix following amputation allowing miscarriages, or by the dense scar tissue following other procedures making labor prolonged and difficult. Thorough destruction of the infected tissue, with either the actual cautery or electrosurgical current, clears the condition and leaves a soft, pliable, normal appearing cervix. Occasionally a thin diaphragm obstructs the canal, requiring a dilatation in the office on one or two subsequent occasions.

Less extensive involvement can be taken care of satisfactorily in the office, particularly if the patients are coöperative and will stand the moderate discomfort. The inactive pad is strapped to the thigh or placed beneath the buttocks, and the vagina and cervix are painted with a local anesthetic, preferably 20 per cent procaine as it is safe from sequelae with a nervous patient a short nitrous oxide anesthesia is given In all cautery or electrosurgical operations on the cervix, it is well to protect the mucosa and vulva with gauze saturated with boric acid or normal salt solution, thus preventing the steam or acid smoke, in the case of cautery from irritating the tissues A long thin preferably needle-like or slightly flattened electrode is inserted into the canal up to the internal os and the biterminal coagulation current turned on destroying the tissues for two or three millimeters on all sides deeper destruction is obtained by longer exposures Radial applications are made and nabothian cysts punctured evacuated and sterilized.

In dealing with extensive infection the technic is similar only carried deeper into the tissues requiring anesthesia and hospitalization The coagulated tissue comes away gradually and usually the cervix is quite clean and granulating at the end of two weeks. It goes without saying that this coagulum although sterilized by the current, will in a short time contain large numbers of bacteria. It is important to keep down this secondary overgrowth and thus control the amount and odor of the leukorrhea by topical application of an antiseptic solution such as Scott s mercurochrome or Bohlman s gentian two or three times a week, together with alkaline or saline douches on alternate days

Electrocoagulation is more rapid and deeper than cauterization with the actual hot cautery necessitating care against too much slough a possible source of secondary hemorrhage When I first began this work I witnessed two or three such hemorrhages due apparently to deep sloughing but by carefully controlling the current this complication has been overcome

After the sloughing is complete in one to two weeks the cervix

short-circuiting through the vaginal mucosa or vulva The snare is snugly placed about the pedicle and gradually tightened through it as a strong cutting current is applied to the handle, sealing blood vessels and lymphatics as the polyp drops off The base may then be more deeply coagulated if necessary by reapplying the current through a long straight or curved electrode

Robert Fowler has described a unique method of an indirect snare with the patient on an autocondensation pad attached to the uni terminal Oudin circuit of the electrosurgical generator a snare is placed about the pedicle in the usual manner the current passing through the operator who acts as a condenser

Submucous myomas which have descended through the cervical canal are readily attacked with an electrosurgical snare as just described. Should the pedicle be long a strong cutting current is required on a cutting edge or narrow flat electrode to dissect into the uterine cavity removing any lingering pieces Not infrequently submucous myomas do not present at the external os being found on routine examination of the uterine cavity Kelly has had several experiences of splitting the anterior lip of the cervix with a cutting current and resecting these otherwise unapproachable tumors Electrosurgery greatly reduces the amount of hemorrhage when these tumors because of their size require piecemeal removal

The differential diagnosis of cervical ulcers a constant and important problem is greatly simplified by biopsy now available as an office procedure, placing at the disposal of every gynecologist the early diagnosis of cancer It is a simple routine to take out a piece of suspicious tissue for microscopic examination with a wire loop in a suitable handle as an active electrode carrying a strong cutting current. The edges of the specimen will be coagulated to a limited degree, the center furnishing enough unaltered tissue for adequate study Any large vessel which may bleed is easily controlled by the application of the coagulating current on a blunt electrode

Electrosurgical treatment of *carcinoma* of the cervix is only an adjuvant to irradiation and should never be relied upon as the only method of destruction of malignancy in this area. Radium is now well recognized as the method *par excellence* for the treatment of malignancy of the cervix. (See Section III) However electrosurgery acts as an aid in the removal of excessive growth permitting the radium application to outlying posts of the growth s advancement In spite of recent extensive public education regarding cancer we are constantly confronted with patients in advanced stages of the disease with complete destruction of the cervix, or with a great cauliflower mass filling the vagina. Here the cauliflower growth is removed with an electrosurgical loop or snare or the cervix amputated flush with the vaginal vault. This is by no means a routine measure as the smaller lesions are readily treated by irradiation alone

canal. A proper cutting current with sufficient coagulation to control bleeding is necessary

The active electrode is inserted into the canal and the current turned on As the wire cuts through the tissue the electrode is rotated throughout an axis of 360 degrees cutting out a cone of cervical mucosa and opening all infected glands for drainage If necessary the instrument may be reintroduced, removing all diseased tissue. Any bleeding from large vessels is easily controlled by applying the coagulation current on a blunt electrode Infected nabothian cysts present beyond the area removed are punctured with a needle carrying a coagulating current. This wells out the contents, sterilizing the cavity and eradicating the infection

A gray slough will be found filling the cervical canal about the end of the fourth day and on the seventh day the canal is much smaller and granulating nicely Between the second and third weeks the cervix is almost normal with several small unhealed areas here and there At the end of the fourth week healing is usually complete. Hyams advised against vaginal douches as unnecessary because of the small amount of sloughing and consequent leukorrheal discharge. He claims that conization is especially convenient for the treatment of ambulatory patients relieving symptoms by the removal of the infected mucous membrane and opening of the glands thereby facilitating drainage and reducing congestion deeper in the cervix. Since no muscular tissue is removed the cervix remains functionally normal and subsequent parturition is unhampered Diseased tissue is removed to any desired depth by repeating the procedure as often as advisable.

Electrosurgery is the method *par excellence* for removing *papillomas* of the cervix and pedunculated fibroids presenting at the os Usually papillomas are sufficiently large to require a general anesthetic occasionally small ones can be removed in the office either by electrodesiccation or electrocoagulation or by cutting the pedicle with an electrosurgical current. For the larger ones the usual preparations are required as for any other vaginal or cervical operations. After adequate exposure, traction is made on the polyp and the pedicle then severed with a strong cutting current and its base coagulated destroying any possible lingering cells assuring against recurrence Should the pedicle *originate high in the canal or uterine cavity* the cervix is split anteriorly (Kelly), using a fine cutting current a strong one preventing primary union after closing the incision With the canal laid widely open the pedicle is outlined and cut across with a stronger current.

Another unique method of attacking cervical polyps is with an electrosurgical snare first described by William L Clark for the removal of bladder tumors through a suprapubic incision. Since then it has been employed for pedunculated tumors in almost every accessible part of the body An ordinary tonsil snare is satisfactory although special instruments have been devised embracing the same general principles The shank is insulated with rubber tubing preventing

sarcoma of the uterus located in the left broad ligament displacing the uterus to the right and elongating the uterine cavity to twenty centimeters and bulging into the vagina, causing profuse and alarming hemorrhage Thinking the tumor a myoma preparations were made for vaginal removal. Incision in the vaginal vault exposed a highly vascular soft pliable and encapsulated sarcoma from which hemorrhage was so brisk that operation had to be abandoned with the patient in a collapsed stage but not before the mass had been excavated by a combination of electric scalloping and morecellement. This then permitted application of radium up into the tumor, otherwise impossible

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Intramural and subserous fibroids are also removed with a strong electrosurgical cutting current through an abdominal incision, bleed ing being distinctly lessened, reducing the shock. In this manner operations for the removal of large myomas, otherwise impossible, save the uterus for normal function and often for subsequent pregnancy

Extensive *transabdominal pelvic operations* have been performed with the electrosurgical cutting current with the advantage of sealing over capillaries and lymphatics Seven or eight years ago when Howard A. Kelly first took up electrosurgery, it was my privilege to be his assistant at most operations At that time he used a cutting current for practically every form of pelvic operation, hysterectomies, panhysterectomies myomectomies salpingectomies and oophorectomies this extensive application being made in an effort to determine the value of the cutting current as an operating instrument in addition to its prior claim in the treatment of malignancy It is fair to say that this is a safe and efficient method for these operations but its advantages are limited. The small vessels in the broad ligament and ovarian regions can be clamped and coagulated with safety, but the larger ones particularly the uterine and ovarian, must be ligated as usual *It is a safe rule always to ligate any large vessel in the pelvis or* abdomen when possible rather than rely upon coagulation alone The cutting current in itself is particularly advantageous in dissecting densely adherent areas. How frequently tubes ovaries, myomas etc., found attached to loops of bowel or other organs in the pelvis offer tedious and bloody problems for scalpel surgery with severe shock to the patient. In such a carefully regulated cutting current readily severs the adherent organs with so little bleeding that at times there results a practically dry incision. Loops of bowel are thus quickly and easily dissected with less danger from the reformation of adhesions because of the protective coagulum remaining a few days before absorption

Densely adherent *ovarian cysts* benign or malignant and considered inoperable with the scalpel are extricated by the current with great facility in most cases the entire cyst wall being dissected away Where this is impossible the actively growing cyst wall is sliced off by the current, leaving the harmless outer portion attached to the intestine or abdominal wall to be absorbed later Occasionally with malignant cysts where even this procedure is impossible on account of extensive erosions of the adherent viscera the lingering portions are exploded out of existence by a strong coagulating current leaving a perfectly sterile dry field

Robert Fowler reports successful electrosurgical *vaginal hysterectomies* and a *cesarean section* mentioning the only serious complication following electrosurgical abdominal hysterectomies of which I am aware, although I have never seen it. His patient died of embolus attributed to some electrical injury to a large pelvic vessel. He also describes a new way of approaching a huge otherwise inoperable

mind at all times particularly when a malignant cervix treated and healed by irradiation begins to ulcerate in a few months or even in two or three years Biopsy readily distinguishes between a delayed radium "burn and recurrent malignancy and is a diagnostic requirement before subsequent radiation is carried out.

So important is this that I cite a case A white woman Mrs N B M. age forty-eight had an abdominal panhysterectomy in June 1929 followed by a prophylactic radium treatment. The patient was in excellent health until December 1929 when on routine reexamination a small ulceration was noted in the vaginal vault. Another radium treatment was given without biopsy and she continued well until three weeks before being referred to me in March, 1930 Within these three weeks a foul watery vaginal discharge developed associated with marked vesicle and rectal irritation pain and bleeding On examination the whole vagina, which was rather small was seen covered with typical grayish-white radium slough. Cystoscopic examination revealed a large reddened and irritated area on the trigone opposite the treatment site Proctoscopy demonstrated a more marked reaction in the rectum at the level of the old cervix. A long period of severe pain and reaction followed and subsequently a large rectovaginal fistula occurred which has only partially healed The bladder is still a source of great distress with repeated accumulation of urinary calculi over the sloughing ulcer although there is no evidence of recurrence of the growth. It would appear that this stormy convalescence could have been avoided by biopsy of the recurrent ulcer determining the need or lack of need of the last irradiation Over irradiation is easily possible in the thin walled vagina, especially after removal of the cervix, which acts as a filter when present.

Deep x ray or heavy radium-pack treatments used for transpelvic irradiation are associated with a mild skin erythema beginning about a week after application and lasting a variable period blondes being more sensitive than brunettes This erythema gradually fades in the course of two or three weeks and the skin takes on a bronzed appearance not unlike a sun or ultraviolet tan which remains for many months without discomfort

There are two biologic changes following intra uterine irradiation (1) endometrial and (2) ovarian Cloudy swelling and erythema, infiltration of leukocytes and phagocytes, fibroblastic organization obliterating endarteritis and scarring—all occur in the endometrium and underlying muscles of the uterus The obliterating endarteritis accounts for the reduction in bleeding and partly for the amenorrhea. There may be some specific effect upon the uterine musculature large fibroids readily disappearing and the uterus returning to normal

The ovary presents a variety of structures all of which are sensitive in proportionate degrees to irradiation with x ray or radium. The ova and epithelial follicles are more sensitive than the stroma The sensitivity of the follicles themselves depends upon their stage of develop-

SECTION III

IRRADIATION THERAPY

Physics

As a detailed discussion of the physics of irradiation therapy is given elsewhere (see Desjardins and Burnam, Vol III) attention here is focused upon the application of these therapeutic agents in gynecology

Biophysics

Reference should be made to these chapters (see Desjardins and Burnam, Vol. III) for study of the biophysical reactions of irradiation therapy although it is important to rehearse some of the changes noted in treating gynecologic diseases

As the gamma rays of radium or x ray enter living tissues chemical processes are started which do not appear immediately but are evidenced later by marked local changes in the diseased areas. The first noticeable alteration is an erythema resulting from dilatation of the blood vessels In ulcerative growths, say of the cervix, this erythema may appear in two or three days and remain a varying length of time until the cervix is healed or until there is sufficient accumulation of fibrinous exudate on the surface to cover the underlying redness. Microscopically a cloudy swelling of the cells is seen within twenty four to forty-eight hours the cytoplasm being distended and pale, the nuclei swollen and pyknotic, and in three or four days the entire cell is undergoing rapid degeneration The capillaries and blood vessels are enlarged and distended with blood, plasma has filtered out into the surrounding tissues and leukocytes and phagocytes are abundant in the perivascular structures As the injured cells degenerate, the phagocytes commence their work of clearing away the débris. In the second and third weeks, fibroblasts and new blood vessels grow in organizing the tissue and producing a fibroblastic structure that becomes so very dense as to be characteristic of irradiation cicatrix. This same fibrosis involves the vessel walls, so that those which were once dilated and engorged with blood immediately following the treatment gradually return at first to normal size their lumina then continuing to become slowly and steadily closed by an obliterating endarteritis. This process does not always cease with the scarring but may progress, depending upon the amount of treatment to the extent of obliteration of most of the vessels with markedly reduced nourishment and subsequent breaking-down and ulceration at a period remote from the time of application This is not common in gynecologic conditions unless heavy treatments are given, and then is most commonly seen in the thin walled vagina. This possibility should be borne in

mind at all times particularly when a malignant cervix treated and healed by irradiation begins to ulcerate in a few months or even in two or three years Biopsy readily distinguishes between a delayed radium 'burn and recurrent malignancy and is a diagnostic requirement before subsequent radiation is carried out.

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Deep x-ray or heavy radium-pack treatments used for transpelvic irradiation are associated with a mild skin erythema beginning about a week after application and lasting a variable period blondes being more sensitive than brunettes This erythema gradually fades in the course of two or three weeks and the skin takes on a bronzed appearance not unlike a sun or ultraviolet tan which remains for many months without discomfort.

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The ovary presents a variety of structures all of which are sensitive in proportionate degrees to irradiation with x ray or radium The ova and epithelial follicles are more sensitive than the stroma. The sensitivity of the follicles themselves depends upon their stage of develop-

ment, the mature ones showing most marked changes The number and degree of follicles destroyed vary with the dose and the steps in their reaction to the irradiation are comparable to spontaneous, physiologic atresia With the death of the follicles, sterility naturally occurs and may or may not be permanent according to the severity of the treatment The interstitial cells are not directly influenced by irradiation but gradually and slowly disappear, probably due to the destruction and eradication of the follicles, preventing the interstitial cells from being renewed.

Radiation Sickness

Radiation sickness is a term describing certain symptoms arising as a sequel to radium or x ray treatments In gynecology this most commonly follows deep-therapy treatments with x-ray or radium packs, to a lesser degree after intra-uterine and cervical irradiation, more marked when such treatments are given under general anesthesia, which causes part of the symptoms.

The symptoms vary in intensity depending upon the amount and duration of treatment and sensitivity of the patient passing off in a few hours or lasting a day or more. Usually there is only anorexia and nausea in others nausea and vomiting which in severe reactions may continue for twenty four or forty-eight hours and occasionally longer

These symptoms are more pronounced when irradiating the abdomen particularly the stomach and liver although they have been known to occur following intensive irradiation of other parts of the body the generally accepted view of the cause being that certain toxic products of cellular destruction are liberated into the blood stream and act as poisons Irradiation of the intestines containing a large amount of semidigested or residual organic matter naturally gives more marked symptoms because of the larger quantity of toxic products liberated in the bowel and later absorbed into the blood stream.

Treatment of this uncomfortable complication is at best unsatisfactory as no specific is available. The preparation of the patient before irradiation is an important aid in limiting the symptoms The bowels are thoroughly cleared of fecal matter a source of secondary radiations with either a laxative the night before, or an enema the morning of the treatment. Fasting for several hours is also of benefit in lessening the nausea. Elimination of foods for several hours afterward usually reduces the amount of vomiting although most patients do not want food for some hours or perhaps a day if the symptoms are at all marked. A most important factor contributing to irradiation sickness is the overcrowding of treatment long heavy, deep-therapy treatments through the pelvis whether with radium or x ray tend to cause more sickness than broken doses allowing the patient to react from one treatment before another is administered. Drugs giving the

most benefit are rather simple remedies Alkalinization with bicarbonate of soda or other medicaments during the day prior to the treatment may be of benefit citrous fruit juices and crushed ice sometimes relieve the nausea. Fifteen or twenty drops of compound tincture of cardamom and fifteen or twenty drops of compound tincture of hyoscyamus with twenty grains of bicarbonate of soda given three times a day often allay the vomiting Fortunately irradiation sickness gradually passes away and rarely causes any serious complications, although frequently distressing to the patient.

Artificial Menopause

Cessation of the menstrual cycle following irradiation of the pelvic organs is a common and often desired sequela permanent or temporary according to the strength and type of treatment. It is always permanent following irradiation of carcinoma of the cervix and body of the uterus. Irradiation for benign bleeding particularly in young people (under thirty five) can be so carefully regulated that the artificial amenorrhea can be made to vary from six months to two years This is not uncommon even with large fibroids for as the tumors disappear and the uterus returns to normal the ovaries again begin to function and the menstrual cycle returns An interesting case has been reported by Curtis F Burnam (personal communication) of a woman who married rather late in life then was irradiated for fibroid with cessation of the menstrual periods for about a year Following this she became pregnant and gave birth to a perfectly normal child.

Transpelvic irradiation with high-powered x ray or radium packs in proper doses causes artificial menopause Mild irradiation (one third to two-thirds sterilizing dose) particularly in women under twenty five or thirty will sometimes control an abnormal menstrual flow without complete cessation the ovarian functions apparently being only partially influenced If the full amount of transpelvic irradiation permitted by the skin (erythema dose) is given the menstrual cycles are almost certain to be completely checked particularly in women over forty variations within certain limits proving the rule

Irradiation Technic

Complete discussion of the technical problems of irradiation treatment may be found in Volume III (DesJardins and Burnam) but it is important to describe briefly the technic as applied to gynecologic disease as each is discussed

External radium treatments by the pack method are administered in two ways The early technic employed an open pack of felt balsa wood or other light substance to maintain the exact distance between the radium and the skin. On the top of this pack was a small metal

box, usually 1 or 2 mm. of lead in which the radium or radon tubes as the case might be, were held The use of platinum filtered tubes necessitates another filter of aluminum foil to filter out the secondary platinum rays and ametal rubber for the secondary aluminum rays the rubber not being so important with large packs of considerable thickness of felt or wood through which the rays travel

The newer method utilizes a large lead cylinder or bomb carrying the radium in such a manner that the rays reach the patient through an opening on one side or one end, the scattered rays being absorbed by the lead wall of the container So far as I am able to ascertain, this

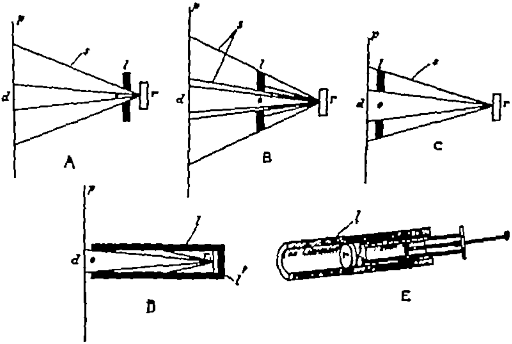


FIG. 14.—Diagram of the principle of plain lead filters as compared with Ward cylinder Lettering in all diagrams is as follows (r) box containing radium emanation; (l) lead filter with portal (o) (p) skin f patient (s) rays. A, lead filter (l) next to radium. B lead filter (l) midway between radium and patient. C, lead filter next skin. D illustrates rays absorbed by cylinder walls, only those destined to reach lesion being unobstructed (l') represents one inch of lead in cover of radium carrier (r) affording protection of nurse's hand during insertion or removal from cylinder E, longitudinal sectional view of cylinder containing radium carrier the latter being equipped with handle facilitating manipulation. The length of the handle and carrier together corresponds to length of cylinder A scale is so arranged on handle that as carrier is moved in cylinder the number of inches read at distal end indicates distance of filtration.

type of apparatus was first used by Stenstrom at the State Cancer Hospital in Buffalo He arranged a mechanical device to rotate the charge of radium tubes of unequal strength within the cylinder in order to make the beam of rays that reached the patient as nearly uni form as possible. The author independently of Stenstrom s work, designed a lead cylinder (Figs. 14 and 16-19) with a two-inch aperture and a lead wall of one inch thickness This apparatus was put into use

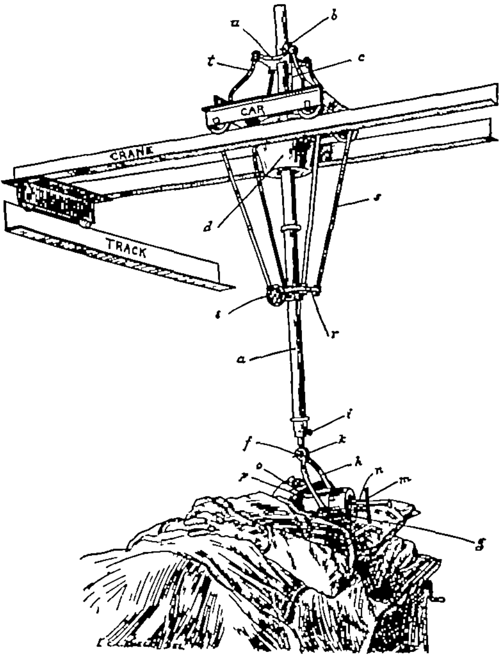


Fig. 15.—Suspension apparatus and cylinder "set up" as in treatment of a parotid tumor. (a) shaft (b) pulley carrying cable (c) which suspends shaft and counter balancing weight (d) (e) safety hand screw (f g and l) thumbscrews for adjusting cylinder (k) cogs preventing ball (h) from slipping (n) scale on handle (m) f radium carrier (o) aluminum filter cap (p) sheet rubber filter (s and t) braces ending in brass plates (u and r) which prevent any swaying of shaft.

at the Howard A. Kelly Hospital in the early part of 1923 This cylinder weighs twenty five pounds and is carried by a car running on a crane travelling on an overhead track (*Fig.* 15) Patients are placed on the Burnam treatment table (Fig. 20) with lead protection beneath, preventing irradiation of any patient or hospital workers in the room below A few years ago the Memorial Hospital in New York City made a much larger radium bomb to carry permanently several grams of element. Such apparatus assures accurate application without injury to the surrounding parts and without unnecessary general body irradiation from the scattered rays which occur with the open package.

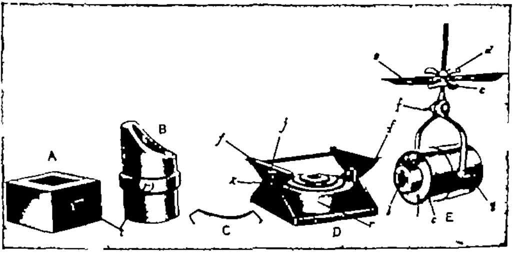


FIG. 16—A "square cylinder The advantage here is that in treating adjacent areas square portals leave no portion of tumors unradiated (t) holes for thumbscrews which hold cylinder in suspension apparatus. B a cylinder with proximal end cut to fit curved surface of skull, used in treating an inoperable brain tumor from five angles without overlapping. C, aluminum filter cap curved to fit cylinder B D set of treat ment rings shown in car to carry them running on track of portable suspension table shown in Fig. 9 (r) lead rings (f) flanges to fit tracks (j) thumbscrew which tightens against track and serves as brake on the car (k) thumbscrew adjusting angle of car and rings with skin. E, 2-inch cylinder with adjusting apparatus as used with portable suspension table shown in Fig. 19. In figure a longer cylinder (b) with a 1 inch portal projects from inch portal of larger and shorter cylinder and is used in treating glands and smaller tumors (a) wall of -inch cylinder made of 1 inch of lead (c) ¼ inch brass reinforcing lead (f and g) thumbscrews for ad usting cylinder to any angle with the skin (o) car for portable suspension table seen in Fig. 19 (d and e) wing nuts for adjusting height of cylinder

In gynecologic procedures such instruments are especially valuable particularly in treating diseases of the vulva where the thighs must be carefully protected against scattered radiation when the pack is placed between them. Cross firing upon a tumor is possible without overlapping on the skin otherwise often a source of severe superficial burns This cross firing through several portals around the pelvis multiplies the number of rays actually reaching the disease in direct proportion to the number of exposures

Intratumoral application of radon or radium element is of great therapeutic value in gynecology Tumors of the vulva, large massive cervical growths and broad ligament extensions are oftentimes treated by the implantation of platinum filtered radon seeds (see Burnam

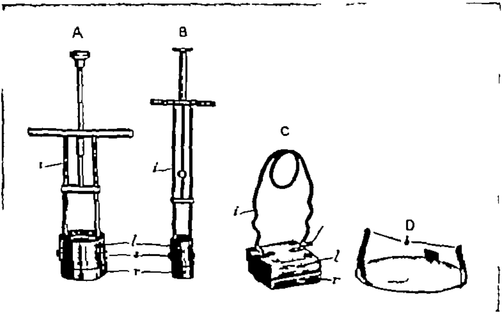


FIG. 17—A, radium carrier for two-inch cylinder B for one inch cylinder C, square cylinder (l) one inch of lead in cover of carrier (in square carrier C it is ½ inch in thickness) (r) radium container of hard rubber reinforced with brass (no brass on bottom so that filtration is only through a thin layer f rubber) (s) brass stubs so arranged that movements of crossbar of handle upward force them against the inner wall of cylinder thus fixing carrier at desired point In C spring of handle serves to force stubs against cylinder wall (i) scale in inches indicating distance of radium from mouth of cylinder D aluminum filter cap for two-inch cylinder This slips easily ver proximal end of cylinder and is held in place by brass springs (b) at sides.

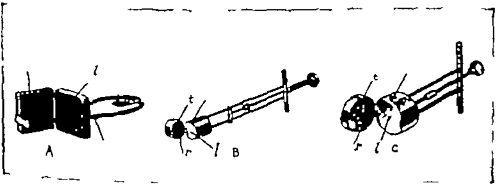


FIG. 18.—B and C, radium carriers for one inch and two-inch cylinders respectively open t show pockets (t) for radium tubes (s, l and r) as in Figure 17, A, carrier for square cylinder open to show plain brass box ( ) witho t separate holes for each tube. This is used when radium tubes vary in size.

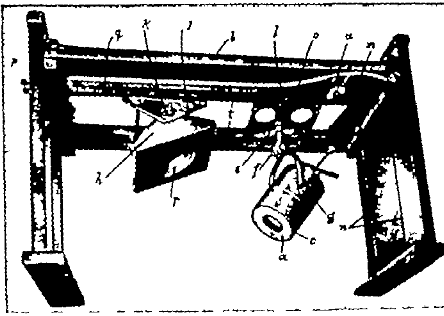


FIG. 19.—Portable suspension table; (n) two vertical slots in end of table through which pass bolts from adjustable top (b) allowing it to be fixed at any desired height by tightening thumbscrew (p) (t) track (b and o) cars. One track is pivoted at (q) end (m) being movable so that by spreading the cars may be taken off or put on (u) thumbscrew for tightening movable end of track (l) brake for car (o) thumbscrew removed. Other lettering as in D and E, Fig. 14.

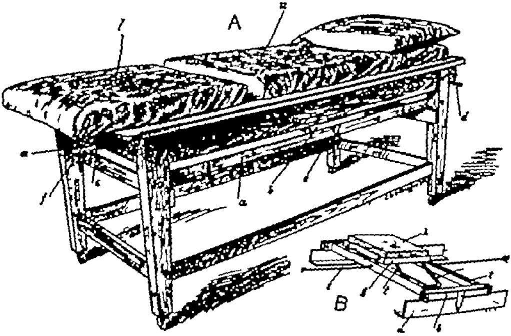


FIG. 20.—A, Burnam treatment table (a) Track of two-inch angle iron (b) end of crane with arrow indicating center (c) handle for moving car, (d, e and f) crank, rope and pulley respectively used for moving crane (l and u) lower and upper mattresses respectively separated to show construction. B, insert showing crane (b) and car (g) carrying one inch lead block (h) 18-inch square; (t) tracks on crane for car (g) (c, e and) as in A

Vol. III) or radium element needles made out of an alloy of platinum and iridium

Flat vulval or vaginal growths are best treated by plaques fitted to the size and shape, with protection of the surrounding normal structures. During application to a malignancy on one labium the other is protected with lead or the cylinder just mentioned may be pulled

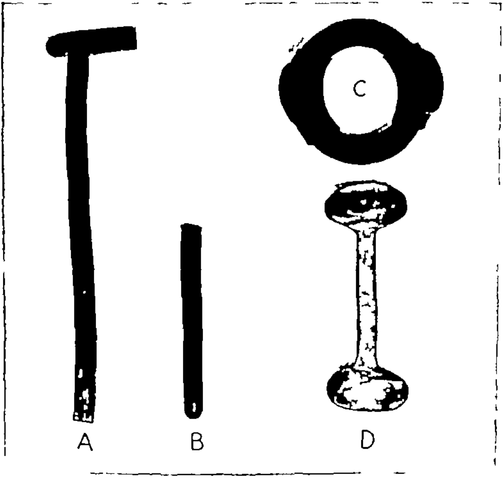


FIG. 21—Ametal rubber cervical uterine and vaginal applicators.

A. T-tube—radium charge placed in hollow cross tube to be laid directly against cervix—often inside of pessary "C.
B Tube for insertion into uterine or cervical canals.
C. Pessary—made in various sizes to fit around the cervix Radium beneath filters on each side radiating broad ligaments filters hold vaginal walls away
D Dumb-bell applicator for holding radium beneath bases of broad ligaments, when pessaries do not fit cervix.

down tightly against the involved one, and the radium placed as close as necessary to give the desired dose.

Vaginal treatments require a great deal of care on account of the proximity of the bladder and rectum and the thinness of the vaginal

wall, the entire thickness of which may be burned through without difficulty The maximum dose against a vaginal wall tumor should be about 1 000 mg hr per 2 sq in. when the filter is 2 mm. of brass. One millimeter of platinum allows an increase of 30 per cent as there are fewer soft gamma rays The gauze plaque (Fig 22) has varying numbers of little pockets in which the tubes are separately secured Such plaques are also used in treating the cervix. Within the last year

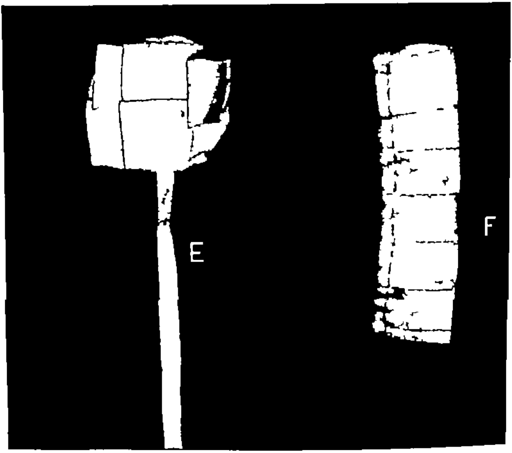


Fig. 22—Cervical gauze plaques.

E Round plaque with number f pockets varied to suit size of cervix.
F Vickers gauze applicat r After filling pockets with radium tubes, purse strings are pulled tightly making circular plaque.
(E and F developed at Howard A Kelly Hospital.)

and a half I have been using radium element in tubes of platinum and iridium of 1 mm. wall thickness This filters out all the beta and the softer gamma rays but gives rise to harder secondary rays from the action of the gamma rays of radium on the platinum. To filter out these secondary beta rays the tube is surrounded by a thin film of aluminum foil and and intracervical treatments is placed in an of 2 mm. thickness. Ametal rubber

pessaries and dumb-bell applicators (Fig 21) hold a tube on each side of the cervix radiating the broad ligament region I have not found this method as satisfactory as placing the individual tubes or plaques against the cervix as each case presents individual problems and the pessaries are not pliable enough to meet all the demands

Heymann of the Radiumhemmet in Stockholm has various sizes and shapes of silver boxes of 2 mm of lead (Figs 25 28) By carefully adjusting these to the cervix or vaginal wall he is able because of their heavy filtration to give a much higher dosage than is

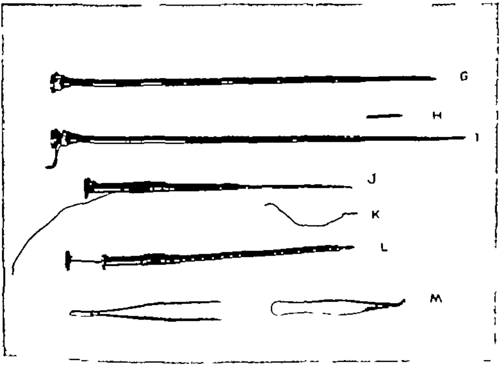


FIG. 23 —Intratumoral equipment.
G Long, hollow implanter with obturator for inserting radium element needles.
H. Ten-mg. radium element needle.
I. Radium element needle projecting from end of implanter
J Radon seed implanter with seed projecting from end
K. Platinum-covered radon seed.
L. Radon seed implanter with obturator
M. Forceps for loading implanter

common in this country Cross firing may be added to this local application by placing tubes in the uterine cavity Inasmuch as radium rays travel in all directions from the tubes any placed in the vagina will tend to radiate into the broad ligament region the same being true of those placed up in the uterine cavity so that radiation from both foci increases that delivered into the broad ligament, adding destruction to any migrating cells

Intra uterine irradiation of menstrual disturbances, fibroids and malignancy is the most direct method and therefore usually most effective. Brass filtered radium tubes (2 to 3 mm. thickness) are placed in a container on the end of a uterine sound and dipped in wax to absorb the secondary rays from the brass Platinum tubes require the special filters previously described filtering out the secondary platinum rays with aluminum foil and 2-mm ametal rubber cots securely tied at the end Intra-uterine applicators require thorough

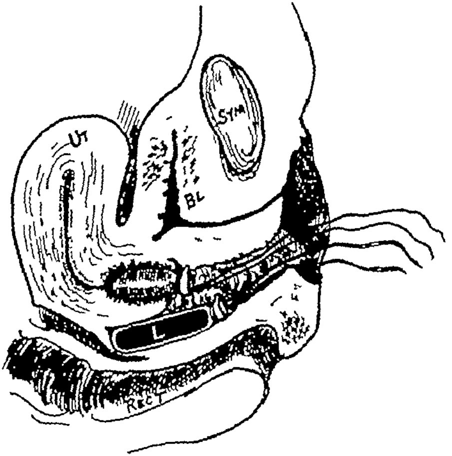


FIG. 14.—Method of protecting rectum after inserting radium tubes into cervix, lead filter protecting rectum vagina packed with gauze.

sterilization either by chemicals or by boiling The ordinary precau tions taken for dilatation and currettage are necessary for intra-uterine irradiation of benign conditions and rarely is there any complicating infection. However in using the uterus as a focus from which to cross fire upon the broad ligaments in treating a carcinoma of the cervix, special care must be exercised in cleansing the cervix so as to avoid carrying the ever-present infection associated with the malignant cervix up into the uterine cavity I have had one or two severe pelvic

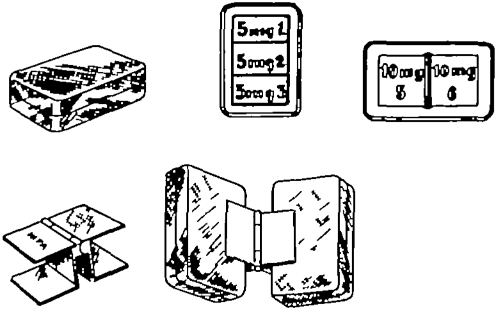


FIG. 25—Boxes for vaginal pplication varying in size from 16 by 25 mm. to 36 by 56 mm. Height of all, 7.5 mm. The filtration is 1.3 mm. lead and 0.45 mm. silver

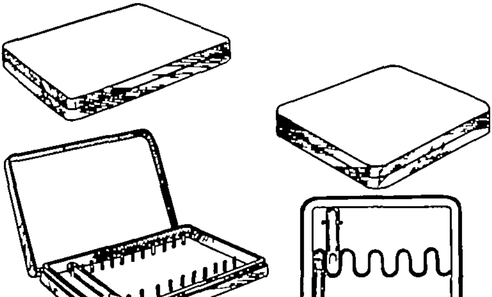


FIG. 26.—Flat boxes for vaginal application—filled with flat containers—filtration similar to Fig 25 Some held together with clips to treat more than one surf ce at the same time.

inflammations follow such an application. In Europe this is the regular procedure and apparently without serious results

Asherson reports three cases of cancer of the cervix treated by the transperitoneal route in addition to local application to the cervix. Four tubes, each containing 10 mg of radium sulphate and screened with 0 3 mm. of platinum, were imbedded around the growth in the base of the broad ligament and in one case in the left ureterosacral fold. He feels that this adds materially to the amount of radiation poured into the cervix, but the technic has not been universally adopted and it is not without dangers

Application of Irradiation

Vulva.—Treatment of vulval diseases calls for careful protection of the thighs as already outlined and a dose carefully calculated for each lesion, guarding against possible burning

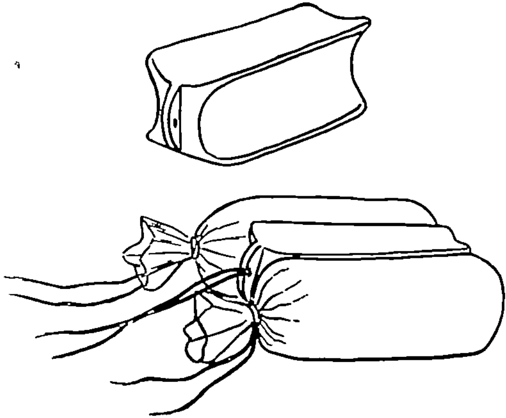
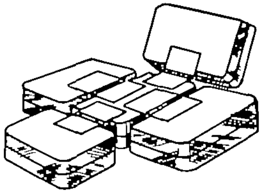


Fig. 27—Celluloid sledges for holding cylinders or capsules in place within a craterous cervix, keeping the radium far out toward the sides nearer the broad ligaments. The narrow area of anterior and posterior wall of the crater from 4 mm. to 1 mm. in width, depending upon width of sledge, remains uncovered by radium, but receives practically as powerful a radiation from cross firing from the two sides. There is the added advantage of somewhat reducing what would otherwise be an added intensity of radiations at those spots (rectum and bladder) where, according to experience, injuries most frequently arise.

Pruritus vulvae a distressing malady is markedly relieved by the local application of radium close to but not on the skin. The dose usually varies from 300 to 400 mg hr at ½-inch distance over an area about two inches square Should the disease extend posteriorly about the anus, an additional area is necessary the same dose being given over each. One treatment usually stops the itching and improves the condition in the ordinary cases but involvement of the deeper skin layers requires a repetition in four to six weeks depending upon the result of the first application



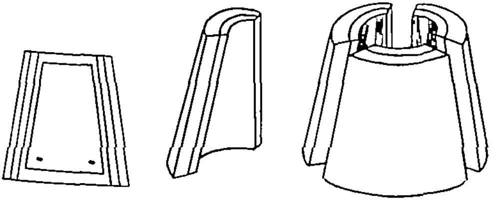


FIG. 8.—Small flat boxes held together with clips for applicatio t cervi and vagina or both at once. Container shaped to suit a cauliflower growth.

Venereal warts are commonly multiple and extensive. The smaller ones are frequently eradicated with electrodesiccation the extensive cases oftentimes demand electrosurgical excision (See Section II) Radium and x ray however are exceedingly important adjuncts either in conjunction with electrosurgery or as the sole therapeutic agent The treatment here is somewhat heavier than that necessary for pruritus vulvae running up from 500 to 600 mg hr at ½ inch from

the skin repeated in four or five weeks, if necessary Occasionally a third or fourth application will be required completely to eradicate the disease By this careful broken-dose method, reactions are avoided and the warts gradually melt away leaving a healthy-looking normal, soft skin.

Carcinoma and *sarcoma* of the vulva are treated with irradiation therapy, frequently in combination with electrosurgery particularly in the resistant and extensive cases The abundant loose skin about the vulva permits easy electrosurgical excision following irradiation, assuring quicker and less painful healing and a softer scar Here, the irradiation dose must be heavier than that for the benign condition in order to affect the more resistant malignant cells Usually 1,000 to 1 500 mg hr are given at ¼ inch distance over two square inches of area, deeper involvement requiring implantation of radium element needles or radon seeds. Heavy irradiation reaction is not so much feared when the tumor is to be taken out electrosurgically after irradiation, as the removal obliterates the slow painful healing A combination of therapy is as a rule more efficacious, as an increased radium dose is possible and two therapeutic agents are used in place of one. The lymph gland bearing areas are given a prophylactic erythema dose with x ray or radium pack, and any large demonstrable metastasis implanted with radon seeds or radium element needles Post-irradiation care consists of cleansing the part regularly and the application of a mild ointment for protection and keeping the parts soft.

Vagina.—*Benign polyps* of the vagina are uncommon and readily removed with electrosurgery, as already outlined.

Carcinoma of the vagina offers an insurmountable task from any surgical standpoint however, as a rule the condition is sensitive to irradiation which gives five year clinical results and splendid palliation in the more extensive cases Intravaginal irradiation is coupled with accurate transpelvic treatment with radium packs or x-ray covering all of the gland bearing areas During the local application the highly sensitive rectum and less sensitive bladder are carefully protected by packing off with gauze or covering the applicator with filters of ⅛ or ¼ inch of lead wrapped in aluminum foil to absorb the secondary lead beta rays These organs are easily damaged with liability of fistulas making the patient exceptionally uncomfortable, complications which are practically always avoided by carefully applying the radium accurately calculating the dose and then packing the vagina keeping the treatment away from all the normal tissue. When the disease is located near the outlet it is best first to pack the gauze above then apply the radium and fill the remaining cavity with gauze to hold the radium in place. Sometimes particularly in the small vagina commonly found in the elderly patient as a result of senile changes small lead filters are of special protective value Implantation in vaginal cancer is dangerous as the thin vaginal wall allows easy

injury to surrounding organs and it is rarely necessary on account of the relative superficialness of the growth itself yielding readily to direct applications As the radium is laid directly against the growth the determination of the dose and filtration is important. I prefer heavy filtration of 1 or 2 mm of platinum or lead and aluminum foil and 2 mm. of rubber filtering out all the soft rays allowing only the hardest penetrating gamma rays to reach the growth. One thousand milligram hours distributed over two square inches of growth have in my experience given the best results Where the disease has extended on two or more sides in the vaginal cavity the pack must be moved from time to time to cover the entire involvement. I usually use a small amount say 75 to 100 mg for from 10 to 15 hr varying the dose as necessary

Cervix.—*Benign* cervical diseases offer much for irradiation therapy Various reports have been made of the advantage of radium treatments in *endocervicitis* an inflammatory condition which as a rule is best handled by cauterization or electrocoagulation (See Section II.) The same may be said of benign polyps easily removed with the cautery or high frequency current, in which should any malignancy be found the base is thoroughly destroyed and adequate irradiation given as a prophylactic measure

Cervical malignancy is one of the most fertile gynecologic fields for irradiation therapy because of the ease of approach and concentration of dose and sensitivity of the cancer, usually predicted by the microscopic picture Biopsy is a routine confirming the diagnosis and aiding the prognosis Martzloff Broders and others have shown that basal cell tumors (which are less differentiated) are the most sensitive to irradiation while squamous-cell or the more highly differentiated type are less sensitive in direct proportion to the amount of keratinization observed microscopically for the nearer the cells are to the adult squamous type the less response is there to the rays Adenocarcinoma is still more resistant. The microscopic picture then is of great help in prognosticating any individual case but not always the sole factor as there is a great difference in the individual variation within any one particular type.

Statistics show that in the early so-called operable cancers as high a percentage of five-year results is obtained by irradiation as with any operative procedure This is without a primary mortality so that in reality the odds are in favor of irradiation therapy In spite of the efficient cancer propaganda for the last ten or fifteen years we still see a large number of cases 70 per cent in my series coming in the *borderline of inoperable cases* either because of the late development of symptoms the patient s own fear of cancer and therefore neglect of investigation or because of the physician s ignorance as to the proper diagnosis. Surgery offers nothing in this group The author reporting 231 cases occurring during 1921 and 1922 at the Howard A.

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Clinic and others maintaining that small amounts of radium given over a period of a day or two and repeated once a week for three weeks are more efficacious I have found that the latter method gives the best result and have adopted the plan of breaking up the calculated total dose into three smaller ones given one or two weeks apart In support of this theory its advocates maintain that inasmuch as cells are vulnerable during mitosis more are affected by exposure to a small amount of radium over a long period and repetition of the dose on two or three successive occasions destroys a still larger number

Following the first treatment there is a period of erythema, after which the cervix gradually shrinks and whitens being covered with a grayish radium slough Bleeding soon stops and the discharge lessens in proportion to the amount of the cervical contraction and healing In from six to eight weeks the cervix is entirely healed and replaced by a firm cicatrix. This is quite uniformly the case even when broad ligament and perimetrial invasion has been noted at the first examination.

After four to six weeks from the first treatment, it is safe to cross fire through the pelvis with radium plaques or x ray the full erythema dose is given through each of several portals two being most commonly chosen, one over each broad ligament, with careful protection from overlapping on the skin. A third portal may be chosen through the sacrum, if indicated by much extension into the posterior pelvis.

Recurrences are treated as they develop The reappearance of local disease is combated by applications similar to the first the dose usually being one-half to two-thirds that originally given Lateral extension in the broad ligaments in the form of a sclerotic mass or growth posteriorly as a fan-shaped diaphragm on each side and encircling the rectum is best treated by cross firing through the pelvis as previously outlined Larger massive recurrences are implanted after thoroughly sterilizing the vagina with radon seeds when available as they can be left in place although removable radium element needles are just as efficacious On the basis of one millicurie of radon permanently implanted giving 133 millicurie hours of treatment, the dose is varied from 500 to 1,200 mg hr depending upon the size of the mass With radium element needles the dose is the same and calculated on a time milligram basis as in any other local application

The complications which may arise following irradiation of carcinoma of the cervix *depend upon the extent of the disease at first* examination and the skill with which the application is made and dose calculated Bladder or rectal fistulas are rare when careful precautions are observed and provided the growth did not involve the anterior or posterior vaginal walls to any marked degree before treatment was begun

Kelly Hospital showed that even in this surgically helpless group 28 per *cent of the local lesions* were *healed* and 44 *markedly* improved with a clinical four year arrest of 15 per cent. One year later which brought these statistics up to the five year period, there were 10 per cent clinically well and without demonstrable disease.

Early cases presenting as small ulcers on the cervix or limited involvement in the canal are treated without preliminary cauterization. In the more advanced removal of a portion of the cervix with the cautery or by electrosurgery allows the application at the outlying portions of the growth where activity is greatest and the treatment is concentrated. This combination is of special value in treating massive cauliflower growths which fill the vagina The cervix is amputated with a strong cutting current and the base sealed with a strong coagulating current. Where this amputation is impossible or difficult the growth can be removed with an electrosurgical loop back to firm tissue

The application of the radium is made in one of several ways, depending upon the case at hand The canal is filled with an ametal rubber cot containing platinum filtered (1 to 3 mm.) radium surrounded by aluminum foil A plaque similarly filtered is then placed over the cervix and held in position with suitable vaginal packing Ametal rubber pessaries or dumb-bell applicators, with extra thick rubber filters around the tubes to keep them away from the vagina, guarding against burning may be used to hold rubber tubes out under the broad ligament. I have found it rather difficult to apply these pessaries and dumb-bell applicators as they are more or less fixed in *size and shape and not adjustable to many cervices Extension* beyond the cervix into the broad ligaments requires implantation of radon seeds or radium element needles are placed in the cervical tissue opposite the broad ligament or in the massive extensions.

Intra uterine application in cervical cancer is advocated by many as an additional means of cross firing upon the broad ligaments. This is not without danger of infection being carried up into the uterus and an associated pelvic peritonitis Cancers of the cervix always have a large amount of associated infection usually streptococcus. In the few cases in which I have added intra uterine irradiation there has been a high percentage of infection in spite of preliminary cleansing of the cervix. There is less likelihood of carrying infection into the body if the cervix is cauterized but no method of chemical sterilization will eradicate all bacteria lingering deep in the tissues.

With radium filtered with 1 mm of platinum, the average cervical dose is 3 000 mg hr, by the combined application of needles tubes and plaques. With heavier filtration say 3 mm. of platinum the dose is increased to 4 000 or 5 000 mg hr Heymann using the equivalent of 3 mm. of lead gives 6,000 mg hr in broken doses, with impunity There are two schools of dosage—one holding that a heavy short application deals a death-blow to the growth better than repeated treatment, the other supported by Bowing and Fricke of the Mayo

In two other patients in this group there were miscarriages Neill concludes that pregnancy is possible after irradiation in selected cases.

For patients from twenty five to forty years of age the intra uterine dose is increased to 1 000 to 1,500 mg hr producing amenorrhea for from one to two years with return of the menstrual periods in the younger group Rarely is a *patient resistant to one or two intra* uterine treatments and then requires hysterectomy Hyperplasia at the menopause requires 1 500 to 2 000 mg. hr with brass-filtered radium and 1 800 to 2 200 mg hr with platinum filtered radium to bring about a complete cessation of menstruation. Artificial menopause is accomplished without serious complication other than that which would have occurred had the menstrual cycle ceased in the normal physiologic way

Fibroid tumors of the uterus are especially susceptible to irradiation given internally or transpelvically, although intra-uterine application is quicker and more certain The size of the tumor per se is not a contraindication to irradiation therapy but pedunculated subserous growths submucous tumors calcified fibromas an incarcerated uterus an obscure diagnosis or acute pelvic inflammatory diseases require surgical intervention. Uterine fibroids so densely bound down by old inflammatory adhesions that their removal is an unwarranted risk respond to irradiation and, shrinking to normal or nearly so all bleeding ceases Reduction of a densely adherent uterus is sometimes associated with abdominal discomfort caused by pulling on the adhesions a symptom of minor importance considering the patient s general well-being The degeneration of fibroma into sarcoma by irradiation has not been established as such cases reported in the literature were probably malignant from the beginning The fibroid dose of intra uterine radium is about the same or perhaps a little larger than that required for permanent amenorrhea, as previously described. X radiation and radium pack for fibroids act through the effect of the rays upon the ovary more than directly upon the tumor itself Intra uterine irradiation however, has a double action first an obliterating endarteritis of the endometrial vessels and second an inhibition of ovarian activity Some authorities believe that excessive bleeding with marked anemia is a contraindication to irradiation as it is imperative to stop the bleeding immediately Hysterectomy is also not without its dangers in such patients Dilatation and curettage under gas anesthesia or in the nulliparous without any anesthetic are associated with much less risk and bring about almost uniformly a complete cessation of the hemorrhage until the radium has had its effect Submucous fibroids or fibroid polyps require surgical removal as irradiation against these gives rise to sloughs of varying degrees of severity with infection and foul discharge without eradicating the tumor

Malignant Diseases —Adenocarcinoma of the uterus usually occurs at or after the menopause Curettage reveals the diagnosis but

Uterus.—Irradiation of uterine disease has been a blessing to many thousands of patients by sparing them the dangers and mutilations of operations for the removal of one or more pelvic organs.

BENIGN DISEASES—Many thousands of women have had their uteri saved by irradiation control of irregularities in menstrual flow or eradication of fibroid tumors What a pity to deprive unnecessarily a young woman of her pelvic organs and hopes of normal sexual activity, by removing the uterus for a menstrual irregularity or small fibroid tumor Many cases are on record of perfectly normal menstrual and sexual functions and the occasional birth of a normal child after uterine irradiation

Hyperplasia of the endometrium is most frequently encountered at the beginning or termination of the menstrual cycle. In young women under twenty five, the intra-uterine dose is from 400 to 1,000 mg hr, with brass-filtered radium and about one-third more than this when 1 mm of platinum, aluminum foil and 2 mm. of ametal rubber are used In girls at the beginning of the menstrual period up to the later teens, one-half to two-thirds of an erythema dose with x ray or radium plaques over the ovaries gives the same result without the necessity of instrumentation. Following such treatment there may not be a complete cessation of the menstrual cycle, but a gradual reduction to normal flow If amenorrhea occurs it usually lasts six months to a year gradually returning to normal

W Neill reports 30 cases of adolescent bleeding treated with radium at the Howard A. Kelly Hospital. In six of these the hemoglobin varied between 30 and 50 per cent. The youngest patient was 13 years old and the oldest 25 He divided the cases into three groups In Group I there were sixteen patients in whom the periods became normal immediately or within a few months after treatment and remained so In Group II, five cases there was temporary amenorrhea with a later return to normal menstruation. In Group III, permanent amenorrhea was established in six cases. All of these were treated by the intra-uterine method, with a dose varying from 184 millicurie hours to 1,300 millicurie hours the maximum dosage being used in a person 24 years of age who had had such extensive hemorrhages in spite of previous curettements that the hemoglobin was 30 per cent. Hysterectomy had been advised, but refused by both patient and parents. After irradiation immediate cessation of hemorrhage occurred, but irregular bleeding continued for eight months when normal periods became established and the patient s health steadily improved.

In Group I of Neill s cases, one patient married one and one-half years after treatment (12 years ago) and gave birth to a normal child one year after marriage (2½ years after treatment) and a year and a half later (4 years after treatment) there was a stillborn child at full term. Five years later she was delivered of a second healthy child—both children being alive and normally developed at the time of this writing

SECTION IV

HYDROTHERAPY—DOUCHES

Hydrotherapy in gynecology is limited to perineal irrigations and douches and occasionally sitz baths irrigations and douches being most frequently employed as a cleansing agent following perineal operations although ulcerating diseases of the vulva require irriga tions for cleanliness and comfort. Irrigation solutions are usually similar to those for douching the vagina Sitz baths relieve pain and tenesmus and cleanse the external genitalia.

The real value of a douche is threefold—first, and most important, the mechanical irrigation second heat applied more closely to the seat of disease and third the chemical effect of least value, as solu tions strong enough for definite chemical action on bacteria often are irritating and usually do not remain in the vagina long enough for real antiseptic effect neither do they reach the cervical canal the seat of most leukorrheas Saline and alkaline douches are soothing to the irritated vagina or vulva

TECHNIC

Douches are best given by a nurse or an attendant although am bulatory patients using the treatment at home once or twice a day have to irrigate themselves A long curved hard rubber nozzle most commonly satisfactory is attached to a soft rubber bag by a long rubber tube. A special, two-way douche nozzle with a large flange near the distal end to keep the vulva apart is preferable thereby protecting the external parts from irritation from hot solu tions and at the same time making distention of the vagina possible the solution escaping only through the outflow tube. The patient should lie on her back preferably with the hips slightly elevated assuring that the solution gets as high as possible (except in acute cases, when Fowler's position is essential to reduce extension up the cervix and uterus and out into the tubes) Advise against sitting on a commode while taking a douche as the solution does not remain in the vagina long enough nor under sufficient pressure to distend all the folds of the vaginal wall

Acute and chronic endocervicitis are the most common diseases requiring douches although the heat of the douche is of great value in acute and chronic salpingitis

does not always tell of the exact location and the extent of the involvement. For this reason, intra-uterine irradiation is liable of inaccurate application, and for many years panhysterectomy was considered the method of choice Recently Burnam and others have reported excellent results from intra-uterine irradiation, which compared favorably with those of panhysterectomy without primary operative mortality The intra uterine irradiation technic is as formerly described with two or three times the dose—as high as 3,000 or 3,500 mg hr being given with brass-filtered radium and 3,500 to 4 000 mg hr with platinum filtered radium In extensive cases this might have to be repeated as occasion demands, the repetition of treatment in any case depending entirely upon the progress. Marked palliation is obtained even in advanced disease involving the broad ligaments, particularly when the treatment includes transpelvic irradiation

Ovaries.—As already mentioned the ovaries are always affected when treating diseases of the uterus or the cervix.

Benign lesions of the ovaries, then which are treated with irradiation are only those dependent upon functional activity

Carcinoma yields surprisingly well, but I believe an exploratory operation should always be done in the hope of removing the growth or as much of it as possible, and allowing accurate localization of the remaining trouble for more effective postoperative irradiation Irradiation of ovarian tumors without preliminary operation except in rare instances where the tumor is massive and diagnosis is quite certain, is more or less working in the dark. I recall a patient of Howard A. Kelly's who had been operated on in a distant city and the diagnosis of inoperable adherent, bilateral carcinoma of the ovary made without biopsy Operation (at which I assisted) was performed in an effort to determine more accurately the exact nature of the growth and to remove as much as possible before irradiation. Two large chocolate cysts were found and completely removed the patient making a splendid recovery Electrosurgery was necessary to cut the tumors away from the densely adherent intestines

The dose of radium or x ray should be carefully calculated and delivered through as many portals as possible, cross firing upon the seat of the disease. An erythema dose is given through each portal with careful protection of the skin to prevent overlapping

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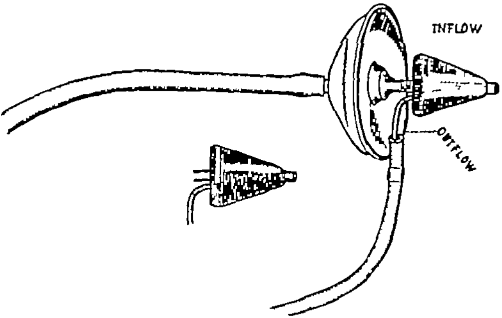


FIG. 29.—Urethral open applicator (Courtesy of American Medicine.)

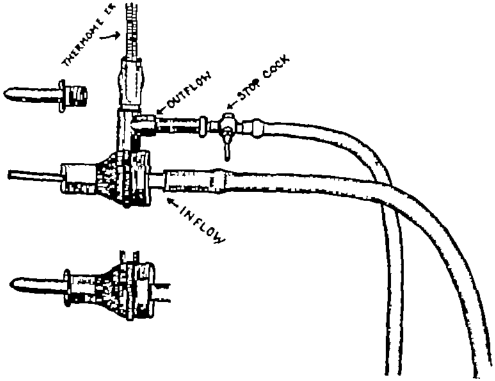


FIG. 30.—Closed urethral applicator (Courtesy of American Medicine.)

Acute Gonorrhea

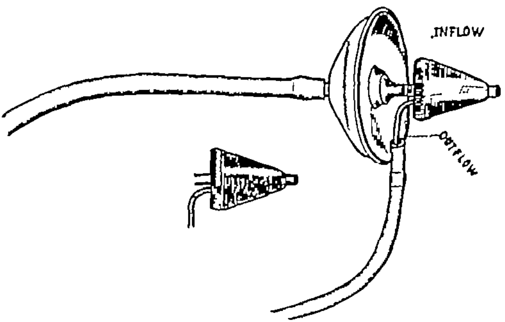
The local treatment of acute gonorrhea is only part of the therapeutic measures necessary to cure the local disease, prevent salpingitis and protect the other members of the household The accepted general medical measures must always go hand in hand with douches and external irrigations

In the acute stages, patients are usually in bed where frequent and constant treatments are more readily given. The perineum and vulva are cleansed three or four times a day by copious irrigations with a mild antiseptic solution, such as 2 per cent boric acid, bichloride of mercury (1 8000) or potassium permanganate (1 4000) Vaginal douches of similar solutions, at a temperature of 116 F (46 67 C) are given at low pressure with the body elevated preventing forcing the acute infection up into the cervix, uterus and out into the tubes. It is better here to use a soft rubber nozzle inserted a little way into the vagina, avoiding any abrasion. The heat inhibits the growth of the gonococci (Cherry), and large amounts of fluid, for instance the long-employed gallon douches greatly prolong the application to the cervix. After the acute stages have subsided, douches are supplemented by topical applications and other treatments which are beyond the scope of this chapter

Hyams [1] has described a unique instrument for, and method of applying prolonged irrigation to the urethra and to the cervix and vagina, with hot solution at an exact temperature under accurate control. The accompanying diagrams are sufficiently illustrative without further description.

Acute Urethritis

The patient is requested not to void for at least an hour before treatment, which is applied in the lithotomy position One ounce of 1 per cent silver nitrate solution is injected into the vagina bathing its walls as well as the cervix, and held by a pledget of cotton in the outlet. The urethral open applicator (Fig. 29) is connected to a tank containing sterile water at a temperature between 114 and 118 F (45 56 and 47 78 C) and the external parts cleansed by irrigation, after which the applicator is inserted into the urethra for about one-quarter of an inch and held firmly against the meatus to prevent leakage. Water is allowed to circulate at a temperature varying from 106 to 114 F (41 11 to 45 56 C) according to the tolerance of the patient, under a little pressure distending the urethra so that its entire surface is accessible and flushed Applications usually last twenty-five minutes then a cotton applicator saturated with 1 per cent silver nitrate solution is inserted into the urethra and left for ten minutes. The pledget previously placed in the vaginal opening is removed the urethra and vulva dried and dusted with a powder con



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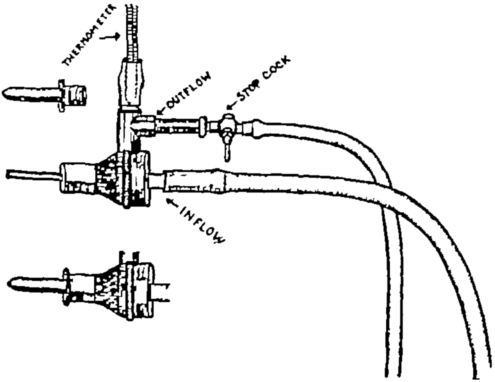

FIG. 30.—Closed urethral applicator (Courtesy of American Medicine.)

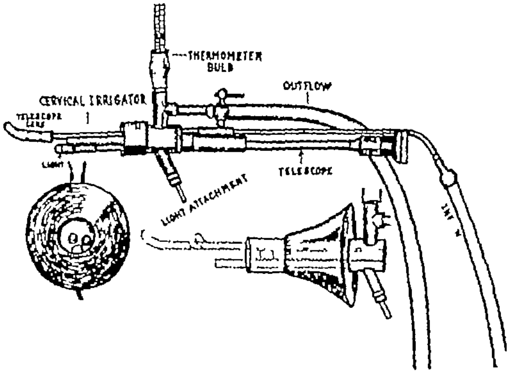

Fig. 31.—Cervical instrument

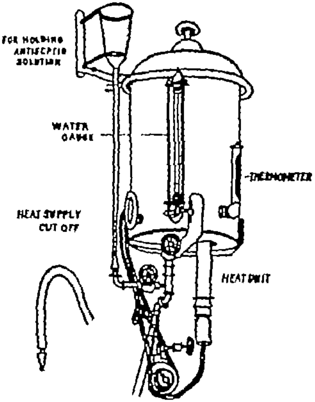

Fig. 3 .—Tank for supplying sterile water at constant temperature.

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CHAPTER TWENTY TWO

MEDICAL DIATHERMY

JOHN S COULTER, M D AND STAFFORD L OSBORNE B.P.E.

When body tissues are subjected to the passage of a high frequency current they become heated. This heating of the tissues has been termed *diathermy* which literally interpreted means heating through. When this heating of the tissues is confined within physiologic limits it is known as *medical diathermy* but when it is carried beyond these limits for the express purpose of tissue destruction by protein coagulation it is termed *surgical diathermy* Gradually this method of heat production has been shorn of many fallacious conceptions which unfortunately only too often hamper the real progress of new ideas The emergence of diathermy from the exuberant empiricism of its early pioneers has been slow but fruitful The period of empiricism has been followed by one of healthy skepticism At last the medical application of high frequency currents has entered that phase of development in which its use and evaluation are based on carefully controlled laboratory experiments

The apparatus employed for the administration of diathermy is known as a high frequency generator and until quite recently there has been but one type used—the so-called spark gap diathermy machine. These generators have an oscillation frequency ranging approximately from one-half to several million cycles per second. When giving a treatment with this form of generator it is necessary to use some form of contact electrodes to conduct the current from the high frequency apparatus to the patient s skin and thus through the underlying tissues.

During the past three or four years diathermy produced by these methods has been almost superseded by the so-called short wave generators. The new method has the decided advantage of simplicity of technic, a lessened tendency to produce burns although burns can still be secured and a more even distribution of heat in the tissues. To distinguish between these two methods the Council of Physical Therapy of the American Medical Association has given the term *conventional diathermy* to the older method and *short wave diathermy* to the newer method. We believe that the subdivision ultrashort wave diathermy should not be used for at present there is no evidence at hand to show that this subdivision is necessary

With short wave medical diathermy there are several methods of application. Medical diathermy may be secured as outlined below

1 Conventional diathermy (or long wave diathermy)
Metallic electrodes are in contact with the skin
2 Short wave diathermy
(a) Electric field
May be applied by means of
(1) Condenser pad electrodes
(2) Cuff electrodes encircling the part to be treated
(3) So-called air-spaced electrodes made of metal contained in glass, bakelite or rubber
(b) Electromagnetic field
Applied by means of
(1) A flexible rubber cable
(2) A formed disk enclosed in a bakelite case

Some workers have also used orificial electrodes but their use is not frequent. We feel that this type of application is still in the experimental field

SHORT WAVE DIATHERMY

The therapeutic use of high frequency currents of much shorter wavelength became possible with the development of the oscillator tubes Almost overnight the usual wavelength of three to four hundred meters for conventional diathermy changed to thirty meters and now ranges from thirty to six meters. Naturally with such rapid development much confusion has arisen and it has been difficult to keep pace with the changing models of the various manufacturers. No less confusing have been the many therapeutic claims made for this realm of high frequency The chief claims for short wave diathermy revolve about the following points

1 Special selective thermal action
2 Specific biologic action
3 Specific bactericidal action
4 A more effective and less dangerous method of heating human tissues than conventional diathermy

Special Selective Thermal Action.—From a mathematical and physical study of the heating of electrolytes in high frequency fields, McLennan and Burton,[1] Pätzold[2] and Reiter[3] have shown that the heating depends on the specific conductivity of the liquid and rises to a maximum for a certain conductivity This maximum is the more marked the higher the frequency The conductivity at which the maximum effect occurs is shown to be proportional to the frequency The distribution of the field in the interior of a heterogeneous body is determined largely by the dielectric constant and the heating by the conductivities. For a given wavelength there is a maximum heating effect produced in a medium, the specific conductivity and dielectric

constant of which are connected with the frequency by the relation $2C = nK$ C being the specific conductivity in absolute units K the dielectric constant and n the frequency

Extending this mathematical and physical relationship to the body McLennan and Burton[4] suggest that a selective heating effect is possible from a knowledge of the characteristic electrical constants of the substances of the body and by suitable choice of wavelength the heating of a particular part of a heterogeneous body may be favored over that of neighboring regions

However, there are at least two very serious and insurmountable limitations to this concept, one being the extent to which temperature per se operates on conductivity to increase this factor Frequencies that might show selective heating at room temperature might be much less effective at body temperature and still less so as the tissue temperature rises as a result of the treatment, since the conductivity rises with temperature. Secondly as Mortimer[5] has shown the blood flow and the rapid interchange of heat in the living body may render the differences of temperature negligible for all practical purposes which McLennan and Burton themselves also point out

Schliephake s[6] work as well as that of others[4, 7] on selective thermal action and uniform and penetrating heating has been done mostly on dead tissue and tissue outside the living body and as Schliephake himself says 'It remains for further studies to determine the presence or absence of parallel selective reactions in the living human hence final conclusions from the facts can be drawn only after comparison with similar observations in living human material

The possibility of special selective thermal action is a very remote one according to Mortimer and Osborne s[8] experiments.

Mortimer and Beard[9] used high frequency currents ranging in wavelength from 6 to 25 meters to ascertain whether one particular wavelength would produce more heat in human tissues than some other wavelength. They stated that they found no apparent advantage in any particular wavelength. It would seem therefore that one is not justified in selecting for use a definite wavelength simply because that particular wavelength is supposed to be the optimum for heat production. Facts do not substantiate this claim.

Schliephake performed his experiments by placing pieces of individual tissues of equal size in the condenser field at the same time taking care to keep the field strength as constant as possible Amputated arms and legs likewise were used He investigated wavelengths ranging from 3 5 meters to 14 meters employing seventeen different wavelengths in all. He concluded that the heating of individual tissues in a unit of time varied when energy of certain wavelengths was used. When treating dead pieces of tissue he observed that the fat was usually strongly heated although the absolute height of the temperature varied. Animal fat gave different values from human fat Furthermore, fatty tissues of different men gave different values. Schliephake s

explanation for this was that fat is a storehouse for various kinds of minerals Schliephake stated that in a leg examined by him, the maximum heating of fat was obtained with 14 5 meters and the minimum with 7 meters. He further stated that there was quite commonly a decrease in the heating effect on all kinds of tissues when wavelengths of 17 meters were exceeded

Gebbert as quoted by Kowarschik,[10] studied the heating effects of 3 meters to 16 meters wavelength from a condenser field on dead tissues such as bone muscle, fat and bone marrow He found the same degree of heating in muscle and fat regardless of the wavelengths he employed

Bachem [11] used 3 5, 5, 7 and 15 meter wavelengths in his studies on dead tissues. With these wavelengths there was little difference in the heating effect in the muscle of the dead tissues He found that the strongest heating of the subcutaneous fat was observed with the 5 meter wavelength, which gave a comparative temperature increase of 4° C, while the 15 meter gave about 2 2° C

Schliephake gave heating curves for muscles close to the bones the medial muscles and the boundary between subcutaneous fat and muscles The maximum heating for these tissues was observed at 14 or 15 meter wavelengths and the minimum at 7 meters

Holzer and Weissenberg [12] in their work on dead tissues showed that there was approximately 200 watts more heating with a 20 meter wavelength than with 10 meters when calculating the heat production in watts per ampere for cubic centimeters of tissue.

In the heating of dead human tissues it is possible to obtain different effects with energy at different wavelengths, but there is a considerable difference in the opinion of the investigators about the heating of fat and muscle

In the heating of muscle Schereschewsky [13] noted that there was a greater heating with a 4 69 meter wave than with 1 meter Gebbert observed no difference between 3 meters and 16 meters Schliephake noted that the maximum heating of muscle was at 14 5 meters. Holzer and Weissenberg found a greater heating of muscle at 20 meters than at 10 meters.

In reviewing the aforementioned results, we can agree with Schliephake in his statement, 'From the results obtained on parts of dead bodies we cannot conclude as to the results on living human beings," and with Kowarschik who states that unfortunately we do not know the electrical constants for most tissues and that what is known is very questionable

The lack of specific action of different wavelengths of high frequency energy in heating human tissues has not only been substantiated in our studies on the human thigh but also in pelvic heating experiments Schultze-Rhonhof and Rech [14] using 6 and 30 meter wavelengths found no depth heating of abdominal and pelvic organs. Coulter and Osborne,[15] in a recent study of vaginal and rectal tem-

peratures attained by utilizing 9 15 16.4 and 24 meter short wave medical diathermy found no significant differences in heating effects in relation to wavelength. When using electromagnetic induction with a 24 meter wavelength a temperature rise of approximately 1 5 to 2 degrees was found above that obtained when using the electric field A study of these data indicates that the rise was not due to the difference in wavelength but to the method and technic of application.

Horowitz *et al* [16] using nine different apparatus with wavelengths varying from 6 to 18 meters agreed with the above findings With a 6 meter field short wave medical diathermy using metal vaginal electrodes they obtained a rectal bladder and vaginal temperature of approximately 106 F Apparently this was not due to the difference in wavelength but to the technic employed.

Up to this time all experiments had been made with the condenser type of electrode. Coulter and Carter [17] made an investigation on living human tissues using short wave diathermy machines of different wavelengths. Their study was made to determine the heating efficacy of short wave diathermy in living human fat and muscle of the thigh employing an electric field of 6 12 18 and 24 meter wavelengths using the cuff electrode technic and an electromagnetic field of 12 18 and 24 meter wavelengths using the coil technic The cuff electrode of the electric field and the coil of the electromagnetic field were selected because previous work by Mortimer and Osborne showed these methods of application to be the most effective of those in general use for heating tissues The machine used in these tests was so designed that the oscillator circuit could be interchanged thus giving the range of wavelengths aforementioned They found no significant differences in the use of these various wavelengths in their heating of living human fat and muscle Recently we [18] made a study of tissue heating using 6 12 15 18 and 24 meter wavelengths and again found no significant difference We used not only the electric field method the coil technic of the electromagnetic field but also made a study of the so-called glass air-spaced electrodes In the studies of tissue heating with air spaced electrodes and with the electric field we concluded that the efficiency of heating is dependent on the size of the electrodes, the energy available from the apparatus the method of application the distance of the electrodes from the skin and the patient's tolerance

Specific Biologic Action.—Gosset [19] and his coworkers reported that various types of plant tumors were killed when subjected to massive exposures in a 2 meter field death being preceded by an acceleration in their rate of growth Later Schereschewsky [20] working with a transplantable Rous sarcoma in mice reported that he had shown a maximum lethal action between wavelengths of 3 75 and 15 meters He stated that the tumors did not feel hot but that on the other hand the microscopic picture of them suggested coagulation

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necrosis. Recently Pflomm [21] asserted that he reduced the toxicity of a rat sarcoma by the use of a 3 2 meter wave the tumor receding in size until the thirty-eighth day, after which it began to grow again.

Schereschewsky [23] has lately reviewed his earlier work and has come to the conclusion that the sarcoma was killed by the heat generated in the tissue and that there was no evidence for specific lethal action of the radiation. Ross [22] exposed twenty-two chickens inoculated with the Rous sarcoma to a 29 meter wave and reports that the duration of life was not prolonged and the growth of the tumor was not retarded. Haas and Lob [24] used a 2.8 and 20 meter wave in the treatment of malignant tumors and observed no specific effects.

Other recent observations on the effect of exposure to high frequency currents include the work of Jellinek,[25] who claims an increase over the controls in the weight of newborn mice that were exposed to a 3 meter wave four times daily for one hour at a time, and of Knudson and Schaible,[26] who exposed white rats to currents of from 25 to 33 3 meters for from half an hour to one hour daily raising the temperature to 40 5° C and found no retardation of growth or change in the power to breed These experimenters [27] also exposed dogs to the same high frequency currents for thirty to sixty minutes and found that the chemical changes in the blood were referable to the concentration resulting from the dehydration. The effect of high frequency currents on the oxygen consumption of frog muscle was studied by Fenn and Latchford,[28] using 3 2 and 27 meters They report no special effect that could not be attributed to the heating effect of the current. Nasset [29] and his coworkers have made an extensive study of the physiologic effects of diathermy currents of 300 meters (diathermy) and 30 meters (short wave) on anesthetized dogs and report that at the higher temperature of from 42 to 44 C. the protein metabolism, judged from the urea production may be doubled with no evidence of a disturbance to endogenous protein metabolism.

Mortimer and Osborne [8] believe that there is no conclusive evidence in the literature to uphold the claim of specific biologic action of high frequency currents (short wave diathermy) nor were they able to substantiate this claim in their investigations. In their opinion the burden of proof still lies on those who claim any biologic action of these currents other than heat production.

Eldinow [30] states that in his experiments he failed to demonstrate any direct bactericidal action or any biologic effect apart from that due to heat.

It is believed that certain previous experiments [2, 9, 17] showed that the therapeutic effects of short wave currents are limited to the effects of heat produced This view is supported by the experimental work of Malov [31] who investigated the death of Drosophila in the electric field of short and ultrashort waves (from 4.3 to 107 5 meters) Malov shows that the death of the fruit flies was due to ordinary

heating effects and that there were no noticeable differences in effect between short and ultrashort waves

Hill and Taylor's[32] experimenting with high frequency currents on an excised heart immersed in a small quartz vessel containing Ringer's solution showed that the behavior of a frog heart cilia and nerve muscle preparation exposed to the 3.4 meter wavelength is exactly the same as when merely heated in Ringer's solution. These authors conclude that the biologic effect is due to heat.

Wetzel and Kiesselbach[33] in their work with wavelengths of 12 and 8 meters observed the effect of heat on tadpoles These were placed in glass containers directly between two electrodes of a high frequency electric field The water temperature rose very quickly in 15 minutes from 15 to 28 C and 5 minutes later to 36 C Those exposed to temperatures of 28 C showed no defect or change on the days following whereas those in the temperature of 36 C died either immediately or soon after Wetzel and Kiesselbach point out that the damage done to the tadpoles was due to heat and explained it by the following treatments The tremendous development of heat was partly reduced by placing 5 mm. of felt between the glass jar and the electrode With this arrangement radiation during 15 or 20 minutes showed a temperature rise of from 9 to 12 C These radiations had no particular effects on the tadpoles Wetzel and Kiesselbach then completely excluded the heat effect of the water This was accomplished by running circulating water through the glass containers The tadpoles were now radiated twice daily a half hour each session No differences were noted as against control tad poles which were not in the field The test groups that had been radiated for 14 days were subsequently treated for another 2½ weeks daily about 4 to 7 hours. At the end of these experiments no differ ences were noted between the treated and the untreated groups This showed that when the heat is considerably reduced or excluded there is not noted any damaging nor any improving factor on the experimental tadpoles These tests according to Wetzel and Kiessel bach support the assumption that the chief cause of the biologic action of the short waves is the heat that is produced by the energy exchange

Curtis Dickens and Evans[34] in a recent article summarizing their investigations on specificity state "If such an effect exists it should be possible for the discoverers to describe at least one clear-cut experi ment which could be repeated by other workers In the absence of such evidence we consider that the great mass of inconclusive observa tions which has been presented is a very insecure foundation for the rapidly growing belief in specific short wave therapy Whilst the possible existence of specific actions of ultrashort waves cannot be denied in our opinion such effects have not as yet been adequately demonstrated We therefore find ourselves in agreement with the conclusions of a recent report to the Council on Physical Therapy

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Mortimer and Osborne[8] believe that there is no conclusive evidence in the literature to uphold the claim of specific biologic action of high frequency currents (short wave diathermy), nor were they able to substantiate this claim in their investigations In their opinion the burden of proof still lies on those who claim any biologic action of these currents other than heat production.

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It is believed that certain previous experiments[6, 8, 17] showed that the therapeutic effects of short wave currents are limited to the effects of heat produced This view is supported by the experimental work of Malov[31] who investigated the death of Drosophila in the electric field of short and ultrashort waves (from 4.3 to 107.5 meters) Malov shows that the death of the fruit flies was due to ordinary

their thermal death point. Liebesny's other observations that bacterial growth may be promoted by short waves may also be explained by 'point heating' which raises the temperature of the micro-organisms to their optimum temperature for growth

Hasché and Leunig [41] exposed cultures of staphylococci and streptococci in distilled water saline solution bouillon and milk and on agar plates to short waves (from 8 to 16 meters) of different intensities for periods of time up to eight and one-half hours and observed no inhibitory or destructive effect on the bacteria

Eidinow [30] submitted suspensions of bacteria in serum to 3 and 4 meter waves eliminating the heating effect and reports that he was unable to demonstrate any bactericidal action

Mortimer and Osborne reviewed the literature on this subject. In their own experiments they subjected broth cultures of staphylococci streptococci, *B melitensis* gonococci meningococci and *B typhosus* to a 6 meter wave for twenty minutes during which time the temperature of the culture rose to 40 C without causing any change in the growth of the micro-organisms They subjected rats with experimental pneumonia for three minutes daily to the 6 meter wave without observing any change in the fatal course.

The experimental work that claims specific bactericidal action for these high frequency currents may be more rationally explained according to Mortimer and Osborne on the basis of 'point heating which raises the temperature of the micro-organisms above their thermal death point without a corresponding elevation in the temperature of the medium. It still remains to be demonstrated whether such test tube results can be secured with infection in the body

At Northwestern University Medical School we have made just over three hundred tissue temperature measurements mostly on human subjects but many on animals some of which are as yet incomplete. Our investigative and clinical data thus far have failed to convince us that there is a direct relationship between tissue heating and wave length. We believe that the technic used in the application of the electrodes is of far greater importance As a result of our studies we have come to the following conclusions

1 The electromagnetic induction method with the cable technic is the most convenient of application and is as effective as any other method in the heating of deep tissues.

2 The double cuff technic is an efficient method for producing heat in the depth of human tissues.

3 Air spaced electrodes used with correct technic and an efficient machine will produce efficient heat deep in human tissues

4 The condenser electrode technic (double pad technic) is capable of producing only slight degrees of heat in the depths of human tissues. It results mainly in high surface and subcutaneous heating. If used with an efficient machine the results should rival air-spaced electrodes

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Kovacs[35] states that claims for selective heating by short wave diathermy in laboratory experiments have not been corroborated in the living human organism and do not hold out hope for any practical therapeutic value

Specific Bactericidal Action.—Studies have been carried out to determine whether the high frequency currents have any specific lethal effect on bacteria. Haase and Schliephake[36] reported a selective lethal action with specific wavelengths on various micro-organisms in vitro at 37 C. This work was extended by Liebesny[37] and his coworkers, who postulate that for every kind of bacteria there is a definite wavelength which has the most harmful effect and most quickly destroys the bacteria and that the growth of certain micro-organisms can even be promoted by certain wavelengths

Confirmation of this work is lacking On the other hand much evidence is at hand in refutation. In this country Hicks and Szymanowski,[38] working with 2 5 meters on streptococci staphylococci, *B diphtheriae* bacteriophage and precipitating antibody for pneumococcus, on the course of experimental infection in animals on specific desensitization and on immunization by irradiated toxins explain the effects on the basis of elevation of temperature produced. Izar and Famulari[39] working with 4, 8 and 15 meters on *B typhosus,* paratyphosus dysentery Shiga Ceylon A and B and proteus X_{19}, report these micro-organisms to be unaffected by a twenty minute treatment. Groag and Tomberg[40] in analyzing the results of Haase and Schliephake that bacteria in culture are killed at 37 C by exposure to the short wave field bring out the interesting explanation that because of "point heating" (similar to the phenomenon described by Esau in his oil and water emulsion in which steam escapes after exposure to the field even though the temperature of the emulsion is only 60 to 70 C) the bacteria may be brought above their thermal death point, which is essentially higher than the temperature of the surrounding medium. They remark that it is not necessary as Haase and Schliephake do to invoke a new mechanism as a specific lethal action of short waves which action in no wise was proved by their experiments. Groag and Tomberg repeated the work of Liebesny with the 4 meter and 15 meter wave on *Actinomyces bovis Trichophyton tonsurans* and *B coli* and reached the conclusion that the destruction of cultures by means of short waves is possible in every case so long as the electrical energy of the field suffices to generate the necessary point heat that brings the organisms above

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of the treatment Felt is not recommended for padding because it cannot be cleaned readily

7 The *connecting cords* of electrodes should be kept well separated and at rest during the treatment Tangled cords give a false current reading and swinging cords cause a fluctuation and variation of heat production. Connecting cords should not come in contact with the patient or with any material that would conduct currents from cord to cord or from cord to conductive materials instead of through the patient.

8 In hot weather and with patients prone to perspire, care should be taken not to allow the toweling to become too moist. When this occurs too much as well as uneven surface heating is apt to take place

9 Heat generation from short wave currents begins gradually and accumulates It takes a moment or so before the patient begins to feel what might be called comfortable warmth Too much current develops heat too fast and the skin may get too hot, resulting in hot spots blisters or burns Never disregard a patient s complaint of "too hot."

10 The current must be stopped immediately when patients complain of a deep painful sensation instead of the anticipated pleasant warmth. Additional padding (towelling) at the point will greatly modify this difficulty The treatment may be resumed at moderate dosage when the patient reports that the painful sensation has disappeared

11 Careful watch for *untoward reactions* should be kept when treating the head as occasionally patients complain of headaches and dizziness in which case it is best to stop the application give appropriate treatment (reclining posture cold compresses) and resume the short wave treatment after the symptoms have abated but with a less intense current.

12 Patients should not be permitted to regulate the current, no matter how intelligent they may be. This implies that either the physician or a qualified technician must remain with or near the patient so as to be on hand to regulate the current whenever it becomes necessary

13 *Treatment timers* are convenient methods of measuring treatment time. The simplest timers are special alarm clocks that can be set to ring at any number of minutes The use of such a clock is usually an assurance that a treatment will not be prolonged beyond the desired period It will insure accuracy of the dosage time. It is also an aid in answering the patient s inquisitiveness as to how much longer does this treatment last.'

14. The *duration of a treatment* will vary according to the pathology under treatment and usually lasts from fifteen to thirty minutes. Many treatments however are terminated in twenty minutes that would undoubtedly be of greater value to the patient were they permitted to continue for a period of forty five minutes or even longer Only too often, unfortunately the value of time has been the deciding factor

5 Conventional diathermy heats human tissues efficiently in the depths but requires more skilled technic for its application

6 It is possible to produce burns no matter what method is used but the electromagnetic field appears to be the safest as well as the most comfortable to the patient.

General Rules for Short Wave Medical Diathermy—1 The *patient* should be placed in a comfortable position to secure complete relaxation. Many clinicians precede the diathermy treatment with an infra red irradiation A high wattage gas-filled tungsten lamp or a high resistance coil, according to the depth of penetration desired may be the source of the infra red radiation.

2 Patients are often quite fearful of electricity and when first applied they have confused ideas of what might happen. Therefore, before the current is turned on for the initial treatment it is always necessary to explain carefully to the patient the sensation to be experienced Moreover during the first treatment it is good judgment to keep well within the patient s tolerance in order to gain his confidence and reactions It should also be explained that too much heat may be harmful and that therefore the patient should inform the operator immediately when heating becomes uncomfortable

3 When there are *sensory disturbances* present due to pathology of the nervous system either of central or peripheral origin diathermy should not be given over the areas involved. Sensation must be intact

Before giving the first treatment, care should be taken to ascertain that the patient has normal sensitivity to heat and cold. If sensation to heat and cold is at all questionable it should be tested. This is easily accomplished by placing two test tubes one filled with hot and the other with cold water to the skin of the patient with the direction to indicate which is hot and which is cold

4 Patients should be required to *remove all clothing* over the part to be treated. They should be instructed to remove metallic objects (money knife keys or watch) from the remainder of the clothing worn This will exclude the possibility of these objects being in the electric field.

5 Metal beds or *treatment tables* should not be used. If the patient touches the metal during a treatment a burn may result at the place of contact. A wooden table 30 inches wide, 30 inches high and 6½ feet long can be built as described in Chapter 21 of this volume A practical wooden treatment table with an upholstered top and adjustable at the head and leg ends has been perfected by one of the authors (S L O)

6 *Turkish toweling* is the best material to use for spacing between the electrode and the skin. Certain other substances such as art leather oil cloth old rubber mats and the like may actually prove semiconductors become overheated and thereby nullify the effect

of the treatment. Felt is not recommended for padding because it cannot be cleaned readily

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in determining the duration of many treatments The duration of the treatment depends on the pathologic condition with which we are dealing The prolongation of the treatment within reasonable limits is logical if the heat in itself is the curative factor If on the other hand we are dealing with a condition caused by an infecting organism little influenced by heat per se, then treatment of ten minutes' duration will be sufficient to start with on account of the danger of exacerbation The reaction of the patient must be ascertained.

15 In order to be sure that no burns have occurred during the treatment, the *skin* should always be scrupulously examined on removal of the electrodes For his own protection, the operator should never deviate from this rule.

Current Dosage —We have no precise means of knowing the intensity and amount of current flowing through the part under treatment. While in conventional diathermy the ammeter is a relative indicator of milliamperage in short wave diathermy the meter is no indication of current strength and merely indicates that point at which duplications can be obtained when conditions are identical. It is also the means of indicating an increase or decrease of dosage. Hence dosage must be regulated by the tolerance of the patient.

Electromagnetic Induction.—This is a most efficient and convenient method available for producing heat in the body The current is conducted to the patient by means of a very flexible heavily insulated cable (Fig 1) or by means of a disk electrode containing the cable coiled and positioned ready for treatment The cable is coiled about or around the part to be treated when the cable is used as the electrode. Surrounding the coil through which the high frequency current flows there is set up an alternating magnetic field having the same frequency of alternation as the current in the coil. Any electrically conductive material placed within the electromagnetic field will have induced in it a voltage causing eddy currents of electricity to flow the frequency of which will be the same as that flowing in the coil (approximately 15 million cycles) If living tissue is placed within the electromagnetic field of this apparatus the effect of the eddy currents induced in the tissues will be the production of heat, and there will be absolutely no neuromuscular response since the frequency of the eddy currents is far above that which elicits muscular contraction. If a body composed of materials of different electrical conductivity—such as human tissue—is placed within the coil the intensity of the heating developed in the various constituent materials will vary with their conductivity the maximum intensity of eddy currents and heating being in the tissues of greatest conductivity Thus heating of the tissues is in direct proportion to their electrical conductivity Merriman, Holmquest and Osborne [12] have shown that this is not true for the electric field and conventional

diathermy Heating produced by electromagnetic induction is not necessarily confined to the body of the patient, for it is produced in any material or substance in direct proportion to the conductivity thereof Close proximity, therefore of any metallic or other conductive articles should be avoided when treatment is in progress so that the patient may receive the full effect. It is also usually necessary to provide a good ground for these machines The manufacturers of the particular apparatus used will designate whether a ground is necessary or not. A good ground can usually be secured by connecting the ground wire under the metal screw holding the metal wall plate in place or by connecting the ground wire to a cold water pipe by means of a metal clip This latter method will always insure a good ground. It is not advisable to use metal treatment tables Mattresses with inner springs should never be used as sufficient heat under certain conditions may be generated in the springs to ignite the mattress material An iron bed can be used provided the coil is kept at least a foot away from any portion of the iron framework A wooden chair is satisfactory where it is desired to give treatments in a sitting position. The section of the cable between the plug in terminals of the machine should be separated at least four inches This is necessary because the capacity between these leads if brought close together will serve as a shunt for the very high frequency current and will by-pass the part being treated thus reducing the efficiency of the current. Energy thus shunted will unduly heat the insulation of the cable For a similar reason it is not advisable to treat a patient resting on an object which is grounded. If this is done, current will be passed into the patient by conduction through the capacitive coupling between his body and the cable Failure of the circuit to oscillate may result from too close coupling' between the electrode cable and the patient. This may happen when the electrode cable is positioned too close to the patient or when there are too many turns or loops in it for a given distance between cable and patient.

The cable may be used in the form of a loop of one or more turns or in the shape of a pancake coil of one or more turns The number of turns used may differ for various machines When making application to local parts sufficient toweling or other absorbent padding should always be placed between the electrode cable and the part being treated When the patient is ready for the current to be turned on he should be covered with a sheet or light blanket to reduce heat loss to a minimum.

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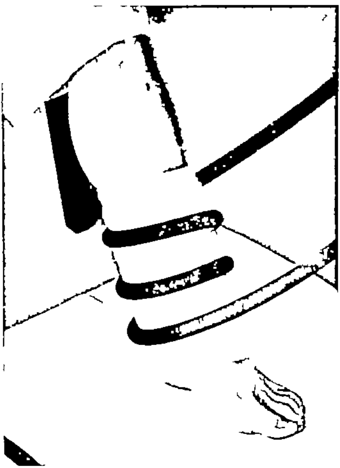

Fig. 3—Application to the ankle. Coil technic

3 Connect cable to the proper machine terminals keeping the leads from the coil to the machine separated by a distance of at least 4 inches

4 The extremity could be supported by a pillow if desired so that the weight of the part will not cause undue pressure on the cable

5 In treating the elbow or knee the joint should be in extension.

6 The machine is turned on and the intensity regulator is set to the degree of heating desired.

A neon indicator or other device is provided to show whether or not the circuit is oscillating Failure of the circuit to oscillate may result from "too close coupling' between the electrode cable and the patient. This may happen when the electrode cable is positioned too close to the patient or when there are too many turns or loops in it for a given distance between cable and patient It is important not to operate the machine when the circuit fails to oscillate because the

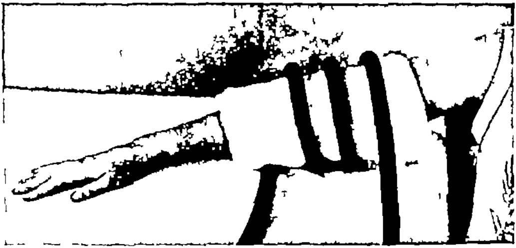

FIG. 1—Application as made to the elbow or upper arm Coil technic.

FIG. 2.—Forearm or wrist application. Coil technic.

TECHNICAL APPLICATION FOR ELBOW FOREARM ANKLE, FOOT AND KNEE (Figs 1–5) —

1 Wrap bath toweling ½ inch thick around the part.
2 Place 3 turns of the cable around the part with each turn separated from the others.

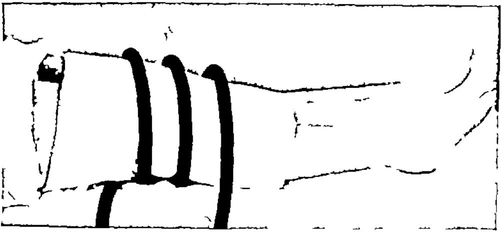

Fig. 6—Illustrating treatment to both knees. Coil technic

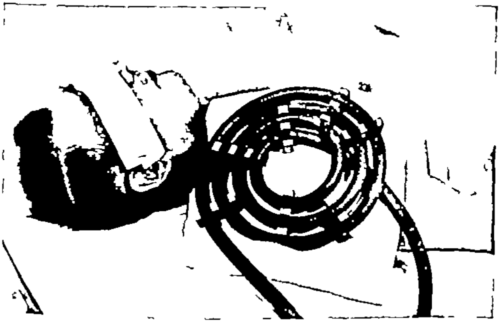

Fig. 7—Treatment to shoulder with pancake coil technic, electromagnetic induction. Coils held in proper space by wooden holders.

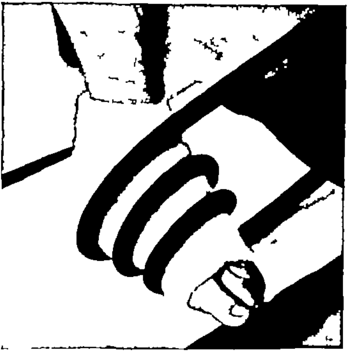

FIG. 4.—Application to the foot. Coil technic.

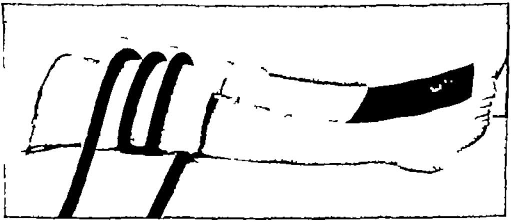

FIG. 5.—Application to the knee. Coil technic.

oscillator tube will overheat and its life become materially lessened or may even be ruined.

It is also important to have the ends of the electrode cable properly and firmly fixed into their respective receptacles

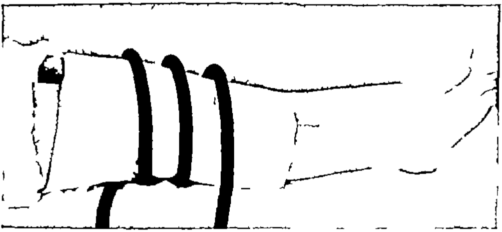

FIG. 6—Illustrating treatment to both knees. Coil technic

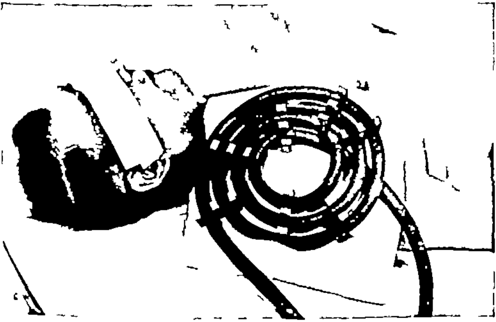

FIG. 7.—Treatment for shoulder with pancake coil technic, electromagnetic induction. Coils held in proper space by wooden holders.

Fig. 8.—Treatment for shoulder electromagnetic induction. Coil wrapped around shoulder.

Procedure for Both Knees (Fig. 6) —

1 Place a folded towel between the knees
2 Wrap bath towelling ½ inch thick around both knees
3 Place three turns of cable around both knees separating the turns.
4 Connect cables to machine, keeping the leads separated at least four inches

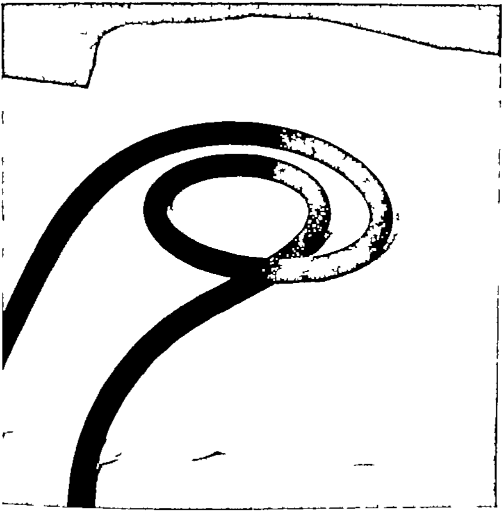

FIG. 9 —Coil in position for ear sinus.

PROCEDURE FOR SHOULDER (Figs 7 8) —

(a) *Pancake Technic* (Fig 7) —

1 Place bath toweling ½ inch thick over shoulder with patient sitting in chair arm resting on pillow placed on table or lying in bed

2 Form cable into pancake coil of three turns with maximum diameter of 7½ inches and place on toweling in apposition with shoulder If necessary bind in place Wooden devices hold coils in place

(b) *Loop Technic* (Fig 8) —

1 Wrap bath toweling ½ inch thick around shoulder and under arm

2 Place three turns of cable around shoulder and under arm as illustrated.

FIG. 5.—Treatment for shoulder electromagnetic induction. Coil wrapped around shoulder

PROCEDURE FOR BOTH KNEES (Fig. 6) —

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2 Wrap bath toweling ½ inch thick around both knees
3 Place three turns of cable around both knees separating the turns.
4 Connect cables to machine keeping the leads separated at least four inches

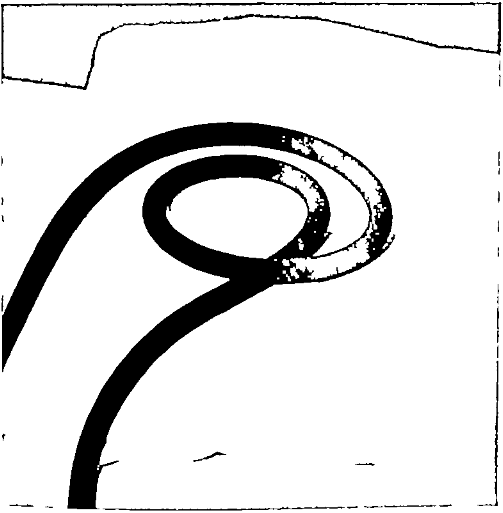

Fig 9—Coil in position for ear or sinus.

PROCEDURE FOR SHOULDER (Figs 7 8) —

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1 Place bath toweling ½ inch thick over shoulder with patient sitting in chair arm resting on pillow placed on table or lying in bed

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(b) *Loop Technic* (Fig 8) —

1 Wrap bath toweling ½ inch thick around shoulder and under arm.

2 Place three turns of cable around shoulder and under arm as illustrated

FIG. 9.—Treatment to the ear

3 Connect cable coils to proper terminals keeping leads from the coil to the machine separated by at least four inches.

PROCEDURE FOR EAR AND SINUS (Figs 9–11) —

1 Place two turns of cable on pillow as illustrated in Figure 9
2 Place bath toweling ½ inch thick over coil.
3 Position patient with region in apposition with coil as illustrated in Figures 10 and 11
4 Keep leads from coil to machine separated by at least four inches.

FIG. 11 —Treatment to sinus

PROCEDURE FOR THE EYES (Fig 12) —

1 Place patient in supine position Place bath toweling ½ inch thick over the part to be treated See Figure 12

2 Form the cable into a pancake coil of two turns and place on toweling over the part as illustrated It may be necessary to support the leads from the coil to the machine to prevent their slipping from the pillow

PROCEDURE FOR THE BACK PELVIS AND HIP (Figs 13–15) —

1 Patient placed in indicated position (See illustrations) Place bath toweling ½ inch thick over region to be treated

Fig. 12—Treatment to the eyes.

2 Form cable into pancake coil of 2 turns having a maximum diameter no greater than 9 inches and placed on toweling over the region to be treated in apposition with the part. If necessary bind in place

Procedure for the Prostate (Figs 16 17) —

1 Place padding ½ inch thick on wooden chair

2 Form cable into a pancake coil of three turns and place on padding as illustrated in Figure 16

3 Place a pillow over coil of sufficient thickness that with patient seated it provides a pad one inch thick between patient and coil (Fig. 17)

4 Connect coil to machine keeping leads separated by at least four inches

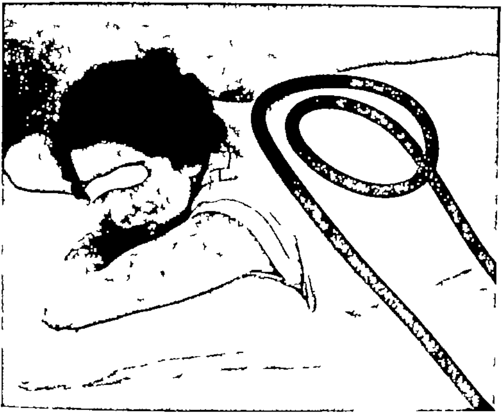

Fig 13.—Pancake coil applied to dorsal region of the spine.

5 Protect inner surface of thighs and testicles from overheating by placing toweling between thighs

THE CABLE DISK ELECTRODE (Figs 18 19) —Treatment locally is made extremely simple by using the disk electrode The cable is positioned within a circular bakelite disk and is readily positioned in apposition to the part to be treated by means of a stand The disks are made in various sizes so that any part of the body can be treated by this method. The use of the disk does not obviate the use of bath toweling between the electrode and the part to be treated.

Electric Field Technic.—CONDENSER PAD ELECTRODES —The condenser pad electrodes are made of a flexible metal plate sandwiched between two layers of flexible rubber so that there will be no danger of the current arcing from the metal to the patient s skin. These vary in size according to the characteristics of the various machines. They are made of a size so that the part to be treated is sandwiched between two of them as in the 'through and through" technic of conventional diathermy Sufficient bath toweling or felt must be interposed between

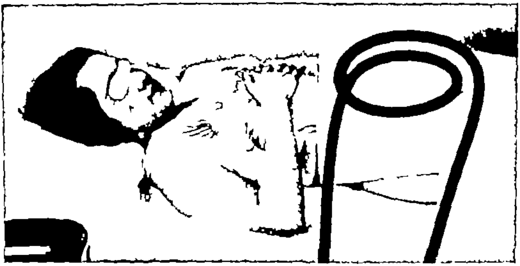

FIG. 14.—Pancake coil applied to the pelvis.

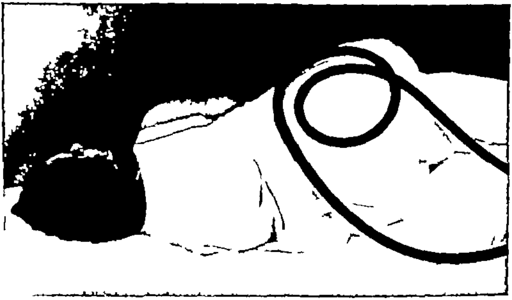

FIG. 15.—Pancake coil applied to the hip

the electrodes and the skin If too much padding is used there will be too little internal heating If insufficient padding is used the superficial tissues will become too hot and burning is very apt to occur Most manufacturers therefore supply the proper thickness of felt to be used for their particular machines. The electrodes when positioned can be bound in place by means of a bandage or held in place with a sandbag (Fig 20) The electrodes should never be applied over clothing of any kind. One must guard against the accumu

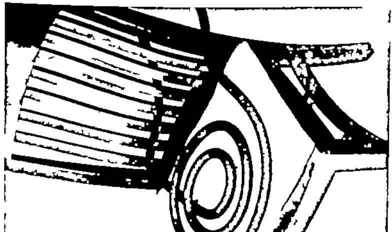

Fig. 6.—Wood chair must be used. Pancake coil in position on chair

Fig. 7.—Pillow placed over pancake coil and patient sitting in position

FIG. 18.—Electromagnetic induction. Illustrating the use of the cable disk electrode. The *cable is arranged inside of the hard rubber disk.*

lation of pools of moisture as perspiration between the patient and electrodes will cause prickling hot spots and if not corrected blisters. Never disregard the patient s complaint regarding hot spots

About the same principles of obtaining heat may be followed in applying the condenser electrodes as are followed with the metal plate electrodes of conventional diathermy that is by using the 'double plate" through and through or transverse method In the so-called "through and through method the part to be treated is sandwiched directly between two electrodes The areas of these electrodes bear varying ratios to each other depending upon where in general it is

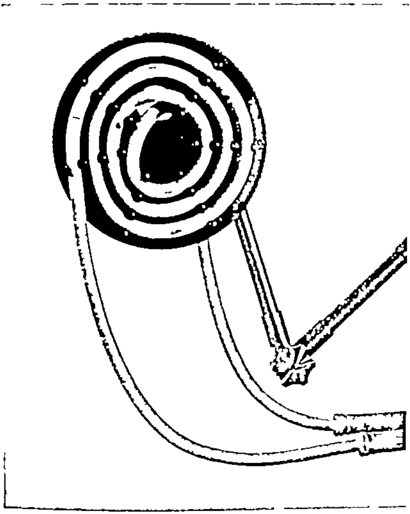

Fig. 19.—Electromagnetic induction. Another method of using cable disk electrode

desired to generate heat. Tissues sandwiched between electrodes of equal area will distribute the heat as evenly as is possible by this method. This may not produce the ideal sought after but it is the best one can do

When it is desired to localize the heating nearer to one surface than another the electrodes must vary in area. The smaller electrode in area is called the active electrode, while the other one is known as the dispersive electrode With small and large electrodes equidistant from the part the heat concentrates toward the smaller electrode. Localization of heating is secured by this method In both these technics it is very important to make sure that the distance directly through the tissues from one electrode to the other is shorter than

Fig. 18.—Electromagnetic induction. Illustrating the use of the cable disk electrode. The cable is arranged inside of the hard rubber disk.

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Therapy have not accepted this mode of application Their heating effect is mostly superficial Undoubtedly a great deal of the confusion about the effect of the application of short waves has been occasioned by a lack of understanding of the electrical principles involved We must consider that it is heat generated in the body by the current that is of value.

A further consideration in the application of condenser pad electrodes is that the portion of the body immediately near the surface and underneath the electrode receives the greatest density of the current thereby causing a tendency to heat up this portion somewhat excessively The fact that so many nerve endings are located near the surface gives the patient a decided sensation of heat even though the depths of that part might be actually raised very slightly in temperature.

In considering the application of condenser pad electrodes where the area of entry for the current into the body is less than the cross section of the part to be heated it is reasonable to assume that the current entering the body is at its greatest density in that portion immediately near the surface of the skin and the heat generated there is greatest thus giving the patient a pronounced sensation of heat As the current leaves the area immediately underneath the pad it spreads out more or less in all directions seeking the path of least resistance through the body As the current density in a particularly conductive area rises it causes the current to seek out the somewhat less conductive areas to pass through. This gives us a very rapidly decreasing current density as the current leaves the area immediately underneath the electrode which we may term the area of entry into the body The current density decreases depending upon the size of the electrode as compared to the possible area through which the current may pass It is a well known electrical law that the heat generated by a current is directly proportional to the square of the density of the current per cubic centimeter In other words if the current is going to decrease very rapidly in density as it leaves the area of entry into the body then the temperature generated decreases as the square of the density per cubic centimeter Therefore it is apparent that the amount of temperature rise generated to any depth is practically nil with pad electrodes that are comparatively much less in size than the cross section of the part we are trying to treat. In addition such other effects as circulation must be taken into consideration. Thus with this technic we get a high surface temperature with very little heat in the depths.

It is essential that when the electrodes are bound in place they maintain a uniform contact and thus avoid variation of heat production during treatment. The current of the patient s circuit is tuned to the capacity of that particular application and if the electrodes are applied loosely the capacity and heat production will vary with every movement of the electrodes. The connecting cords on electrodes

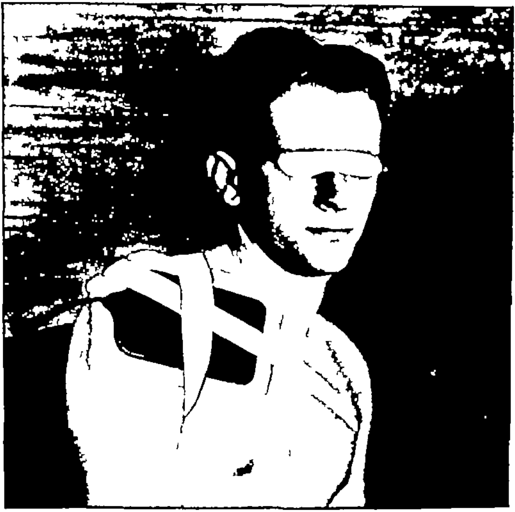

FIG. 10.—Electric field. Condenser pad electrodes pplied to the shoulder

the path circumscribing the part. If the latter path is offered most of the current flow will be on the surface of the part, flowing around from the edge of one electrode to the other The electrodes must also be so placed that the distance is equal from the edge of one electrode to the edge of the other or on both sides of the part under treatment With the edges of one side in closer apposition than the edges of the opposite side there would be a resultant heat concentration in the superficial tissues separating these edges. The heat concentration in this area is caused by a greater current density as most of the current will tend to flow through this shorter path. The use of pad electrodes is the most inefficient technic for the deep heating of tissues with short wave diathermy It is to be emphasized that the Council on Physical

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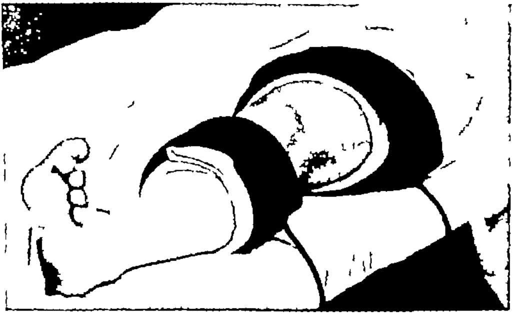

FIG. 11.—Electric field—double cuff method. Application to the knee. Knee is in full extension

should be kept well separated during treatment. Swinging cords cause a fluctuation and variation of heat production Connecting cords should not make contact with the patient or any material that would conduct the current from cord to cord instead of through the patient. Metal tables and chairs must be avoided.

DOUBLE CUFF ELECTRODES.—Cuff electrodes are similar to condenser electrodes except in size Here again sizes vary from a width of three to nine inches and in length from twelve to forty-eight inches. Various manufacturers have different sizes. The double cuff technic is far more efficient for producing deep-seated heat into tissues than is the condenser pad technic. It is unfortunate that this technic is so limited in its application to the various parts of the body Its field of usefulness is practically limited to the extremities

Cuff electrodes should be used so that the area of the cuff electrode is considerably larger than the cross section of the part being treated When this technic is followed a substantial rise in temperature is produced deep in the tissues. They are usually so placed as entirely to encircle the part. Overlapping of the electrode will do no harm. By having the cuffs sufficiently large and sufficiently far apart, any area may be heated to almost any desired temperature within physiologic limits The point is that cuff electrodes must be considerably larger than the cross section of the part being treated, thereby allowing

FIG. 21.—Electric field. Plate and cuff method. Illustrating treatment to the ankle.

the current to enter the patient s body at as low a density as possible in order to remain well below tolerance at that point. Then the elec trodes should be placed as far apart as is convenient (the farther apart the more heat generated) (Fig 21) It is important to apply the cuffs with the extremity in full extension This is illustrated in Figure 21

With small pad electrodes the patient can be given a tremendous sensation of heat with practically no rise of temperature in the depth of the part being treated whereas by using cuff electrodes giving a large area through which the current may enter the patient s body the heating will stay well within the comfortable tolerance of the

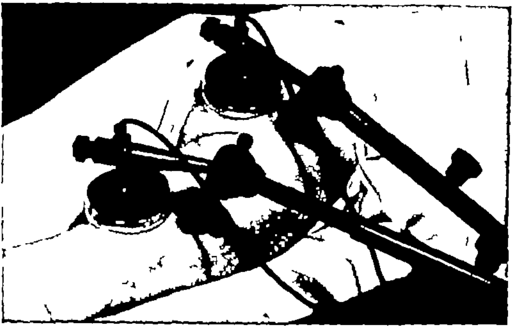

FIG. 23—Illustrating the air-spaced electrodes technic which has been accepted as satisfactory by the Council of Physical Therapy of the American Medical Association. Other applications have not so far proved of value in producing heat deep in the muscles of the thigh.

patient and yet there will be a very substantial rise in temperature deep in the part under treatment.

PLATE AND CUFF TECHNIC.—*Ankle*—The foot is placed on a condenser pad electrode large enough for the entire foot to make contact with ½ inch toweling between the foot and the electrode. A cuff electrode with toweling between it and the skin is applied completely around the calf (Fig. 22)

Wrist—The palm of the hand is placed on a condenser pad electrode large enough for the entire hand fingers and thumb to make contact with toweling ½ inch thick between electrode and the skin A cuff electrode is applied to encircle completely the forearm with toweling between it and the skin.

AIR SPACED ELECTRODES—These electrodes are made of a circular metal disk contained within a special glass container or encased within hard or soft rubber The metal plate is actually the active part of the electrode and can be adjusted to the desired air spacing inside of the glass holder or by suitable adjustment if encased in

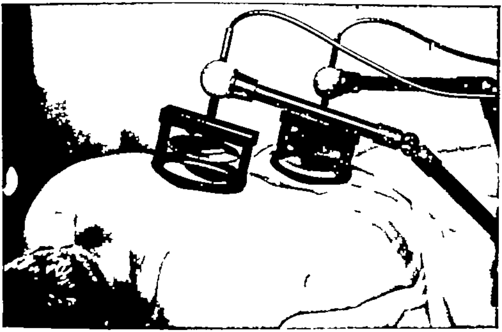

FIG. 24.—Air-spaced electrodes—electric field. Another type shown with the application to the back. Air used as the dielectric

rubber and not in a glass holder These circular electrodes vary in size from 2 to 7½ inches in circumference

The heating effect of air-spaced electrodes depends in part upon the dielectric material used between electrode and the skin. Under constant conditions when air alone is used as the dielectric between skin and electrodes the depth and degree of heating are much greater than when the dielectric is toweling or felt between skin and electrode. An example from our unpublished data will make this clear

Subject 190 lbs.
Electrodes 4½ inch hard rubber disks.
Application. Anterior aspect of thigh and placed in the same plane. Distance of 11 inches center to center Time of application 20 minutes.
1 With 1¼ inch *air spacing*
Temperature at depth of 2 inches 104.9 F
2 With 1¼ inch *toweling* between skin and electrode.
Temperature at depth of 2 inches 100.9 F

A machine must have ample output to operate with a sufficient air gap to secure the proper depth effect. The ability to heat the deep tissues appears to be dependent on the size of the electrode the energy available from the apparatus the method of application the distance of electrodes from the skin and the patient s tolerance This

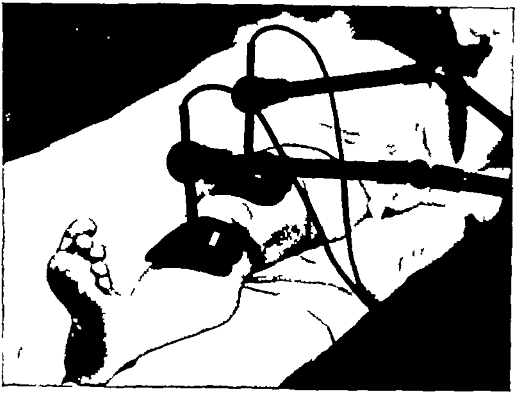

FIG. 25.—Air spaced electrodes of electric field that can be curved to fit the part treated. Application to the knee.

is illustrated by an observation taken from one of our recent articles [18] Using a machine of high output and two 5 inch electrodes a temperature of 106 6 F was produced in the deep muscles of the thigh while with a machine of less output and using two 4 inch electrodes a temperature of only 102 3 F was secured. Furthermore, these electrodes to secure such heating effects must be applied one proximal and the other distal with both of them on the same surface of the area to be treated (Figs 23–25) Used in any other manner these electrodes have not proved efficient in our tests for heating the deeper structures. The glass type of electrode is probably superior to the soft rubber type because it might heat up less A thin layer of absorbent material should always be placed between the skin and the glass of the electrode. This will prevent the formation of a layer of perspiration which might cause overheating and burning.

Burns.—Claims are continually stressed as to the safety and simplicity of short wave diathermy machines. It is true that the technic is simple and that burns are not frequent, but burns can occur unless the proper technic is used Kling [18] reported six cases of burns. Three

cases were second degree burns healing within a few weeks The other three cases were third degree burns with extensive destruction eventually necessitating skin grafts He suggests several methods of avoiding these burns Krusen [44] also reports some cases of burns from short wave diathermy

METHODS OF PREVENTION —*Surface Effect* —The accumulation of heat in the tissues adjoining the electrodes is augmented by unsuitable insulating material of the electrodes and padding used to separate electrodes from the skin. Soft rubber and felt heat up during the treatment. The surface heating can be controlled by a suitable distance between skin and electrode The gap should be filled out with a good insulator that does not heat up during treatment

The interposition of air between the electrode and the skin is the surest means to eliminate the danger of surface accumulation of heat with the electric field electrodes The disadvantage of air spaced electrodes is that the enormous loss of energy requires the employment of powerful apparatus in order to secure sufficient heat in the deep tissues Air-spaced electrodes should be adjustable and may be of metal in special glass holders or encased in hard or soft rubber Soft rubber is the least desirable it heats up readily which decreases its dielectric properties and may also develop small defects through which direct current flows and sparking occurs

With other types of electrodes of the electric field and with the cable of the electromagnetic induction method some absorbent material must be used between the electrodes and the skin. An absorbent material such as Turkish toweling does not heat so much and is to be preferred to such materials as felt.

Electrodes —One of the most important elements in the prevention of burns from short wave diathermy is the proper selection and placing of the electrodes The cable technic by electromagnetic induction heats electrolytes in direct proportion to their electrical conductivities It thus produces maximal heating in the most conductive tissues i e the most vascular tissues The electric field unless carefully controlled produces excessive heat in the more superficial tissues Thus the electromagnetic induction method should be the technic that is least likely to produce burns

In the electric field with cuffs the cuffs must be considerably larger than the cross section of the part being treated and sufficiently far apart, thereby allowing the current to enter the patient s body at as low a density as possible.

It should be remembered that heat generation from short wave currents begins gradually and accumulates. It takes some minutes before the patient begins to feel a comfortable warmth.

In short wave medical diathermy the current density is greatest at the electrodes. Therefore the superficial tissues will be burned

before the deep tissue temperature can be sufficiently high to produce tissue damage.

With pad or air-spaced electrodes of the electric field burns may be prevented by remembering

A Electrodes—1 Heat is fairly uniformly distributed at the point of entry with the electrodes larger than and equidistant from the part being treated.

2 When the cross section of the tissues sandwiched between two electrodes is smaller than the surface area of the electrodes and the space between electrodes and tissues is less on one side than on the other, the heat will be concentrated at the electrode nearer to the tissues

3 With a small and large electrode equidistant from the part, heat concentrates toward the smaller electrode

4. With small electrodes the distance between skin and electrode should be increased to decrease the density of the electric field.

B Perspiration—The density of the field is greater in the moist surface. This can cause overheating and eventually burns. The control of sweating by absorbent material, or interruption of treatment, is therefore necessary to prevent burns.

C The Acro-Effect—This term designates the action of a short wave electric field on pointed parts such as the nose, ear lobes finger tips and bony protuberances such as the olecranon tubercle of the tibia, spinous processes of the vertebrae and base of the phalanges. Kling[44] calls attention to the fact that here the areas are reduced to a minimum the concentration of energy is therefore at a maximum the pointed parts act like antennae It is often noted in the treatment of both knees that the patient feels overheating first at the inside of the knees, owing to this concentration of the field in the pointed protuberances of the medial condyles of the tibia. In such cases it is necessary to protect with sufficient padding between the knees, which tends to spread the field homogeneously

Relationship of Short Wave Diathermy to Radio Communication

The word static' as used in connection with radio reception is well understood by almost everyone An electrical storm provides an excellent example It has been quite well known that the old conventional diathermy apparatus provides so much static that it is almost impossible to use a radio in the same building because of the interference with reception The conventional diathermy apparatus generates high frequency currents of the same magnitude as the broad casting stations While in many instances there was quite an annoyance

to a few people it was no real serious menace to the welfare of large numbers of people. In other words it was of no vital importance.

With the increasing use of short wave apparatus ranging from thirty to six meters in wavelength a quite different situation has arisen. These wave bands have been assigned by the Radio Commission for such uses as ships to shore, aircraft and ground, and the transmission of directional signals, interference with which may easily result in loss of life.

Short wave apparatus we find has been responsible, unwittingly, for a great deal of disturbance of a particularly annoying type.

Last winter important activities of the Naval Research Laboratory at Washington, D. C., were subjected to interference so serious as to stop the work completely.[46] Eventually the disturbance was traced to therapeutic equipment. The first disturbing instrument located was a diathermy unit located in a hospital at Cambridge, Mass.

Broadcasting stations use a large aerial structure to facilitate radiation of energy. Without such a structure connected to a short wave diathermy machine the disturbance, unless exceptionally intense, is unlikely to be felt at a great distance. The diathermy machine at Cambridge was so connected to the power supply line that the latter functioned as an antenna. This enabled the small apparatus to broadcast a "sky wave" of considerable intensity. All that was necessary to stop most of the trouble was the insertion of a suitable electric filter between the apparatus and the power line. In the past these facts were not known, but now that they have been brought to our attention steps will have to be taken to eradicate the difficulty. With this in mind, representatives of the American Medical Association and the manufacturers of therapeutic short wave apparatus have already met with the Radio Commission in Washington to find the best method of procedure for all parties concerned.

The Council of Physical Therapy of the American Medical Association may alter its requirements for apparatus known to have caused radio interference. Manufacturers may be asked to submit evidence that the construction and installation specifications are such as to prevent interference.

If an apparatus does not broadcast an intense sky wave, it may, unless properly filtered, cause disturbances of radio receiving sets which derive power from the same line, thus becoming a nuisance.

Undoubtedly users of existing equipment purchased from reliable manufacturers will be able to secure from the manufacturers additional equipment or engineering advice in an endeavor to prevent interference. The Secretary of the Council of Physical Therapy of the American Medical Association will furnish further information on this subject on request.

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The Selection of Apparatus

According to Heminway and Stenstrom [16] in choosing a machine of the vacuum tube type for diathermy treatments it is necessary to have the machine conform to a certain standard if it is to be of value. The first requirement is that the machine must be able to deliver to the patient sufficient energy Unfortunately some machines are now being manufactured that are deficient in this energy requirement. It is necessary to deliver energy to the patient to raise the temperature of the tissues treated These low power machines do not generate the required amount of heat

The machine should also be well constructed and electrically safe. One of the functions of the Council of Physical Therapy of the Medical Association is to ascertain whether the claims made by the *manufacturer of electrotherapeutic apparatus can* be substantiated, before giving their approval of the device as an acceptable one. While manufacturers are not forced to submit their machines the really reliable ones do so and are anxious to secure the Council approval This serves as a safeguard for the novice in these matters In short wave apparatus the Council of Physical Therapy requires that evidence be presented to them that the machine will produce a given temperature in the deep tissues of the thigh and that it is properly and safely constructed. In addition it is referred to an impartial referee for a clinical evaluation The minimal heating requirement is that it must be as good as conventional diathermy It would seem therefore, that the physician before buying any machine should ascertain from the Secretary of the Council whether it has been approved and if so just what were the actual findings These reports are published from time to time in the *Journal of the American Medical Association* One should however not lose sight of the fact that the accepted machines are not all equally efficient. Some machines just get in with the minimum requirements while others meet the requirements and have plenty to spare Inasmuch as this is an important factor in the short wave field it would seem advisable to look into this matter with some care We believe that heating by electromagnetic induction is the method of choice and hence this type of heating should be available in an adequate machine.

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The Selection of Apparatus

According to Heminway and Stenstrom [48] in choosing a machine of the vacuum tube type for diathermy treatments it is necessary to have the machine conform to a certain standard if it is to be of value. The first requirement is that the machine must be able to deliver to the patient sufficient energy Unfortunately some machines are now being manufactured that are deficient in this energy requirement. It is necessary to deliver energy to the patient to raise the temperature of the tissues treated These low power machines do not generate the required amount of heat.

The machine should also be well constructed and electrically safe.

One of the functions of the Council of Physical Therapy of the Medical Association is to ascertain whether the claims made by the manufacturer of electrotherapeutic apparatus can be substantiated before giving their approval of the device as an acceptable one. While manufacturers are not forced to submit their machines the really reliable ones do so and are anxious to secure the Council approval This serves as a safeguard for the novice in these matters. In short wave apparatus the Council of Physical Therapy requires that evidence be presented to them that the machine will produce a given temperature in the deep tissues of the thigh and that it is properly and safely constructed In addition it is referred to an impartial referee for a clinical evaluation The minimal heating requirement is that it must be as good as conventional diathermy It would seem therefore that the physician before buying any machine should ascertain from the Secretary of the Council whether it has been approved and if so just what were the actual findings These reports are published from time to time in the *Journal of the American Medical Association* One should however not lose sight of the fact that the accepted machines are not all equally efficient. Some machines just get in with the minimum requirements while others meet the requirements and have plenty to spare. Inasmuch as this is an important factor in the short wave field it would seem advisable to look into this matter with some care. We believe that heating by electromagnetic induction is the method of choice and hence this type of heating should be available in an adequate machine

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CHAPTER TWENTY THREE

MANIPULATIVE THERAPY FOR BACK CONDITIONS

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MAURICE B ROCHE, A.B M D

When we consider manipulative therapy in reference to backache the practical value of the procedure may be evaluated by analyzing its effects on various types of back lesions In answering the initial question as to what cases may be manipulated we might include the following which have been enumerated in a previous publication the anatomical variations (sacralization, impinging transverse processes etc.) congenital anomalies poor posture (contraction of tensor fasciae latae marked lordosis etc.) dislocations (spondylolisthesis apophyseal subluxation etc.) fasciitis and myofascial syndromes and sprains (acute or chronic) of traumatic etiology In all the foregoing conditions the element of sprain plays an important role—whether it has been the result either of a direct traumatic incident or because of impaired body mechanics of a kind of trauma active over an extended period of time. And now to turn our attention by way of critical survey to various groups of conditions which respond in similar manner

Group I Conditions responding to manipulation with immediate relief and correction

Cases of acute sacro-iliac and lumbosacral strains respond most satisfactorily to manipulative treatment. Generally the diagnosis is strongly suggested by the history the traumatic incident is definite very often there have been no previous episodes of low back pain and the clinical picture is quite characteristic since the onset of pain the patient may have been locked in a position of forward flexion and lateral inclination or list accompanied by severe pain in the low back perhaps radiating in an acute manner down the thigh Localized tenderness is situated over the affected joint, whether lumbosacral or sacro-iliac

Illustration A medical student in his junior year came in with the complaint of acute backache. He was somewhat over medium height of good muscular development and apparently in good physical condition in spite of his present incapacitating plight. The previous afternoon according to his history in beginning to chop some wood he was suddenly seized with a sharp pain in his low back just as he went through the rotary flexion movement of swinging the ax downward He was immediately unable completely to extend his spine again and

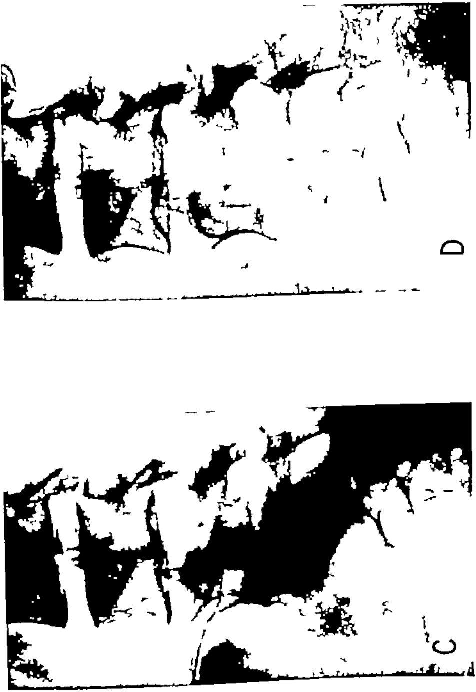

FIG. 1 (Cont.)—(C) Right oblique and (D) left oblique views.

FIG. 1.—Detail plates of third, fourth and fifth lumbar vertebrae and first and second sacral segments in (A) anteroposterior and (B) lateral views.

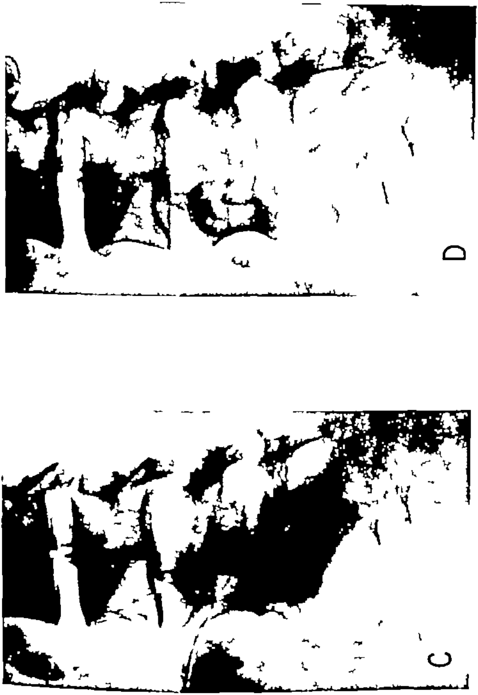

Fig. 1 (*Cont.*)—(*C*) Right oblique and (*D*) left oblique views.

since had assumed the position of marked listing to the left. Shortly after the onset, he was conscious of pain radiating down his right thigh along the distribution of the sciatic nerve. Following the removal of his clothing an appraisal of his standing position posteriorly emphasized the list of the trunk to the left with the right paravertebral muscles visibly taut. The left shoulder was higher than the right. The right posterior superior spine was slightly higher than the left. The right knee was partially flexed and the patient could extend it only at the cost of increasing the sciatic irritation. There was no visible or measurable atrophy of the right thigh or calf muscles There was no palpable tenderness along the various spinous processes or inter spinous ligaments The lumbosacral joint was not sensitive to pressure The right sacrospinalis muscle and right iliolumbar ligament were painful to fairly moderate pressure. The point of greatest tenderness was over the area of the right sacro-iliac joint. An effort to bend forward while keeping his knees extended was immediately inhibited by acute pain which he localized in the region of the right sacro-iliac joint. In the sitting position he could flex his spine more readily although the list to the left persisted Straight leg raising was possible on the right to only about 20 degrees when pain in the region of the right sacro-iliac joint was experienced. Straight leg raising on the left to 85 degrees caused contralateral pain—that is, pain on the right side in the region of the sacro-iliac joint. The knee jerk and ankle jerk on the right side were normally active. Sensory tests for pain and temperature revealed no untoward findings.

We reviewed his history General health had been excellent and review by systems revealed no conditions which might have given rise to a symptomatic backache. There had been no previous attacks. The onset was associated with a definite act involving physical exertion yet this was voluntary and not especially drastic or forcible. We had examined the patient. He presented the typical picture of a low back syndrome. All signs pointed toward abnormal sensitivity and palpable tenderness about the right sacro-iliac joint. There was sciatic irritation but neurologic examination was negative. His x ray plates included anteroposterior lateral and oblique views of the third, fourth and fifth lumbar vertebrae and the first and second sacral segments (Fig. 1, *A B C* and *D*) Well visualized were the lower lumbar vertebrae, the sacrum in its upper portion the intervertebral spaces, the lumbosacral and sacro-iliac joints, and the lower lumbar interlaminar facets. The lumbar vertebrae were of normal outline without any lipping of their edges or other malformation there was no narrowing of the inter vertebral spaces no congenital anomaly the sacro-iliac joints appeared free of any gross bone pathology In the lateral view the lumbosacral joint was not hyperextended there was no spondylolisthesis the intervertebral disks presented normal dimensions In the oblique views no evidence of apophyseal subluxation was present. The x-rays then were negative for bone and apparently also for disk pathology

Equipped with such informative data it was reasonable to favor the tentative diagnosis of acute low back strain involving the liga ments and contiguous muscles of the right sacro-iliac joint accom panied by reflex irritation of the right sciatic nerve The test for such a diagnosis lies in the response of the lesion to conservative therapy The patient was manipulated without anesthesia with his full co-operation so far as voluntary or self induced relaxation is concerned He obtained immediate respite from the acute pain And as is char acteristic with this type of lesion he sensed a readjustment or realign ment of structures which previously had given him the feeling of impingement. With the acute pain subsided and the muscle spasm lessened he moved about more comfortably and with less apprehen sion. He was placed on the post manipulative routine to be described later in these pages and made an uneventful recovery

Group II Conditions responding to manipulation with immediate partial relief and with progressive correction over a period of time

Into this group fall the more chronic cases of lumbosacral and sacro-iliac strain These may represent instances in which the patient has neglected to seek medical aid at the onset of the condition or in which failure to give relief at the onset has occurred The list which was produced by acute muscle spasm in the beginning persists now because of adaptive muscle contractures Time is necessary in order to overcome the contractures and to re-establish muscle balance Low back pain from postural lordosis fits into this same category The contracted sacrospinalis muscles and very often the contracted tensor fasciae obviate any possibility of immediate or dramatic recovery So too with the minor types of congenital anomalies Sacralization of a transverse process may be a source of strain operative over an extended period of time Then there are the cases of an arthritic type, slowly progressive upon which has been superimposed acute or chronic strain such as occurs in various occupational activities. Roentgenograms of this latter type may disclose definite and often marked arthritic changes

Illustration A recent case coming under our supervision was that of a dentist some fifty two years of age whose low back disability was becoming progressively more aggravated by the necessity to stand for prolonged intervals The complaint had been present off and on for a period of years At one time or another he had received most of the known forms of conservative treatment. An examination of his back failed to reveal any list scoliosis or paravertebral spasm Rather marked postural defects were evident—a forward inclination of the head and neck round back flattened chest marked anterior pelvis tilt with pendulous abdomen The left shoulder was somewhat higher than the right—this the patient described as an occupational deformity His posterior superior spines were level as were also his gluteal folds The area of greatest palpable tenderness was over the

FIG. 2—(*A*) Anteroposterior view showing arthritic changes of marked degree involving the lumbosacral joint.

lumbosacral joint There was also definite tenderness over his right sacro-iliac joint. Flexion of the spine in the standing position revealed marked lumbar rigidity accompanied by pain at the level of the lumbosacral joint. Sitting flexion yielded approximately the same effects. Hyperextension in the standing position evoked pain at the level of the fifth lumbar and first sacral vertebrae. Straight leg raising on the right was slightly less than on the opposite side and pain was felt in the region of the right sacro-iliac joint. The roentgenograms disclosed arthritic changes of a most marked degree involving the lumbosacral joint (Fig. 2, *A* and *B*) Gentle manipulation without anesthesia appreciably mobilized his low back and afforded him some immediate comfort. (Incidentally it is quite possible that manipulating a back of this pathology under anesthesia, thus eliminating the delicate check which the patient's voluntary actions supply might precipitate an acute back condition rather than alleviate a chronic one) Continued mobilization plus the other post manipulative measure of therapy afforded him sufficient comfort to continue meeting the

Fig 2 (Cont) —(B) Lateral view

demands of his daily routine A low back well stayed garment tailored to the patient by our corsetière served to save him further episodes of pain In these instances the eventual need for a lumbosacral fusion is always in the foreground.

Group III Conditions responding to manipulative therapy with some immediate relief but no appreciable correction over an extended period of time

Into this group fall (1) cases of ruptured intervertebral disks or prolapsed nucleus pulposus and (2) the facet syndromes

FIG. 2—(*A*) Anteroposterior view showing arthritic changes of marked degree involving the lumbosacral joint.

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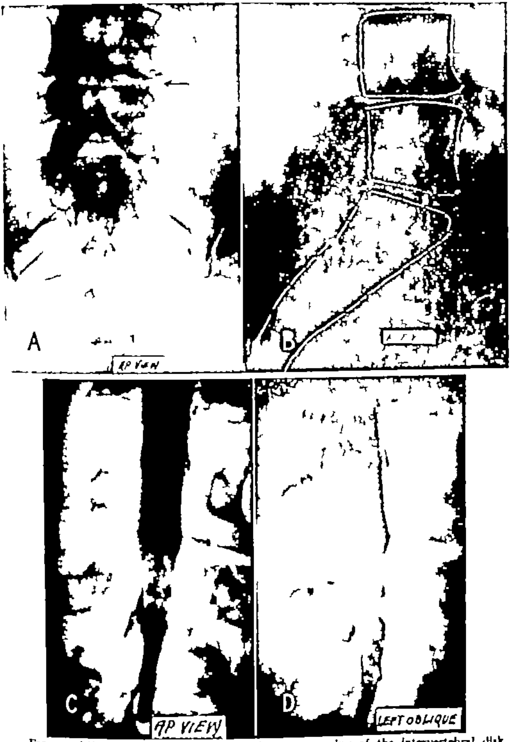

FIG. 3—(*A*) Anteroposterio view showing a narrowing of the intervertebral disk between the fourth and fifth lumbar vertebrae.

(*B*) Lateral view showing hypertrophic osteo-arthritis of fourth and fifth lumbar vertebrae secondary t narrowing of the intervert bral disk

(*C*) Anteroposteri iew (myelography) showing a constant defect narrowing the subarachnoid space at the level f the intervertebral disk between the fourth and fifth lumbar vertebrae

(*D*) Left oblique iew of same defect This defect was seen t compress the nerve roots f L 5 and S 1 on the left side and L 5 on the right side

1 *Ruptured intervertebral disk or prolapsed nucleus pulposus* As was pointed out in a recent communication, this type of intraspinal pathology produces a clinical picture quite similar to low back disability resulting from a number of other different causes There is the recurrence of low back attacks of increasing severity, often an acute agonizing type of pain in the low back with sciatic irritation and the utter lack of response to all types of conservative treatment. We have gently manipulated a number of these cases without anesthesia and obtained a slight transient relief from the acute pain but another paroxysm might immediately ensue so as to make this effort for all practical purposes ineffectual The definite diagnosis of these conditions can be made only by visualizing a defect in the intraspinal lipiodol shadow, such defect being seen at an intervertebral level in different views when the patient on a tilting table is being subjected to fluoroscopic study Spot roentgenograms are made at different angles to verify the fluoroscopic findings Other physical findings such as neurologic changes and the total protein concentration in the spinal fluid are less constant and dependable as accurate diagnostic signs

Illustration A woman thirty five years of age presented herself several months ago complaining of pain in the lower part of her back. Questioned about the duration of the complaint, she stated she was entirely well until four years ago, when she began experiencing an aching discomfort in the back at irregular intervals She further noted these became evident during periods of fatigue She received treatment intermittently from her physician for this "rheumatic" complaint. The symptoms persisted and last July (a year ago) she underwent an operation for removal of adhesions and complete hysterectomy She returned home and in her first attempt to get about she was seized with pain in the lumbosacral region radiating down the right thigh which while varying in intensity has never completely disappeared. The onset of the pain necessitated her returning to bed where she remained through August until the latter part of September She gradually assumed weight bearing and got about after a fashion until the following May when increasing severity of the pain required a period of bed rest for twelve days The last attack occurred this past October confining her to bed until January when her local physician referred her to us

At the time of the initial examination her standing position was characterized by a list toward the left. The paravertebral muscles were taut on both sides, somewhat more so on the left. The right shoulder was higher than the left The posterior superior spines were equal She apparently bore weight equally on both lower extremities, both knees being held in extension. There was no visible or measurable atrophy of thigh or calf muscles. She referred the site of pain and greatest tenderness to the lumbosacral joint level This pain radiated down her right thigh and leg. The pain seemed worse to her in the

FIG. 3.—(*A*) Anteroposterior view showing a narrowing of the intervertebral disk between the fourth and fifth lumbar vertebra

(*B*) Lateral view showing hypertrophic osteo-arthritis of fourth and fifth lumbar vertebrae secondary t narrowing f the intervertebral disk

(*C*) Anteroposterio iew (myelography) showing constant defect narrowing the subarachnoid space at the level of the intervertebral disk between the fourth and fifth lumbar vert brae.

(*D*) Left oblique view of same defect This defect was seen to compress the nerve roots of L 5 and S 1 on the left side and L 5 on the right side

sitting position on a straight chair In walking she noted a weakness of the right foot. In lying down the most painful position was on her back the most comfortable one being on her side with the thighs flexed She complained of extreme sensitiveness of the skin of her right thigh, so much so that she could scarcely bear" to fasten her hose supporters.

The résumé of her back complaint and findings at the time may be summed up as follows a low back pain situated at the lumbosacral level attended with right sciatic irritation repeated attacks of increasing severity, onset unattended by trauma so far as patient can recall localized tenderness on percussion over the fifth lumbar vertebra and first sacral segment lumbar pain and rigidity on forward flexion straight leg raising limited on the right side, positive Lasègue test on right side diminished knee jerk and absent ankle jerk on the right side paresthesia to the following extent diminution in sensation (pinprick) over the posterior thigh corresponding to the first sacral dermatome and some diminution in sensation over the heel and outer three digits of the right foot. Let us progress to the examination of her x ray plates The anteroposterior view (Fig 3 *A*) suggests a diminution in the intervertebral space between the fourth and fifth lumbar vertebrae. If you will now glance at the lateral view (Fig 3, *B*) you will agree that this impression is borne out very definitely A lumbar puncture was done and the findings were indifferent no evidence of block and a total protein concentration of 30 mg. per cent (The total protein may be lowered as much as 20 per cent when taken after the Queckenstedt is done Fluid for total protein determination should therefore be withdrawn before making this test.)

Disregarding the spinal fluid findings because of the definite neurologic findings in the physical examination of the patient, lipiodol to the amount of 5 cc. was introduced into the lower part of the spinal canal and fluoroscopic studies were made on a tilting table Studied from different views and with the patient in different positions a constant unmistakable bilateral defect at the level of the intervertebral space between the fourth and fifth lumbar vertebrae was demonstrated Spot' roentgenograms were then made to verify fluoroscopic observations (Fig. 3 *C* and *D*)

An interesting experiment was carried out during the fluoroscopic examination of this patient. After the defect had been amply seen and studied, the roentgenologist Dr Wendell Scott of the Mallinckrodt Radiological Institute of Washington University Medical School had the patient flex her spine. The defect was seen to disappear the outline of the lipiodol becoming almost straight (Fig 4 *B*) Obviously the ruptured disk and nuclear material *had been reduced* by this manipulation of the spine Then the patient was asked to hyperextend her spine and the definite defect in the lipiodol again became evident. *This result was interpreted on the basis of the nuclear*

FIG. 4.—Myelography (A) Lateral view with spine in normal position. The defect i seen t be anterior and is charact ristic f an intraspinal protru sion f the rt bral disk

(B) Later l iew with the spine in flexion The defect is lessened. Reduc tion?

(C) Lateral iew with the spine hy perextended Defect is seen t be exag gerated

material *having been extruded again* into the canal by the maneuver of extending the spine from the flexed position (Fig 4, *C*)

At the time of the laminectomy the fragmented portion of the intervertebral disk was found to be extruded and this was removed.

2 *The facet syndrome* Disturbances in the intervertebral facets result from an abnormal relationship between two adjacent vertebral bodies A marked lumbar lordosis alters the normal alignment of the intervertebral joints and throws strain on their ligaments. Likewise, a thinning of the intervertebral disk whether because of a ruptured nucleus pulposus or fibrotic changes in the disk itself, will produce an apophyseal subluxation. Such a subluxation may cause low back pain because of strain upon the joint capsules by decreasing the size of the intervertebral foramina, or because of impingement of the ends of the articular processes either against the pedicle above or the lamina below Arthritic changes in these posterior spinal articulations may produce a similar clinical picture In some instances gentle manipulation without anesthesia relieves the sharp pain of an acute attack. Although the exacerbations have been controlled by means of such conservative measures we have in all instances acquainted the patients with the future possibility of a necessary fusion operation

Illustration A young neurosurgeon while leaning over the wash basin was seized with such severe pain in the left low back that he fell to the floor The pain remained acute for several days and then subsided to a continuous ache. Three weeks after the onset, a second attack occurred but lasted only several hours The present attack six weeks after the initial attack was of some forty-eight hours duration The patient on physical examination pointed to the left sacrospinalis muscles at the level of the transverse process of the fourth lumbar vertebra and to the lumbosacral joint as the areas of pain Definite tenderness to palpation was elicited at these points In the standing position a list to the right was evident and this was increased with flexion of the spine.

The roentgenograms (Fig 5, *A* *B* *C* and *D*) disclosed chronic arthritis and obliteration of the apophyseal joints between the fourth and fifth lumbar vetebrae and the fifth lumbar vertebra and sacrum He was manipulated several times with relief from the aching pain and muscle spasm. His list was almost completely effaced at the end of forty-eight hours He was instructed in the proper manner of executing ordinary daily movements so as to avoid future attacks. He understood the vulnerable nature of his back lesion and the possibility for surgical intervention at a later date

Group IV Conditions responding to manipulation with immediate relief and correction for a temporary interval but recurring attacks of increasing severity

This group comprises (1) sacro-iliac subluxations of chronic instability (2) spondylolisthesis and spondyloschisis

FIG. 5—Roentgenograms showing arthritic changes (*A* and *B*) Anteroposterior and lateral views. (*C*) Right oblique showing normal interlaminar facets. (*D*) Left oblique showing chronic arthritis and obliteration of the apophyseal joints between the fourth and fifth lumbar vertebrae and the fifth lumbar vertebra and sacrum.

FIG. 6—(*A*) Anterior projection of symphysis pubis with weight bearing on both feet.
(*B*) With weight bearing on the right foot.
(*C*) With weight bearing on the left foot showing an upward shift of the symphysis on this side.

1 *Sacro-iliac subluxations* Subluxations of the sacro-iliac joint of chronic recurrence, in contradistinction to acute sacro-iliac strains are very often of such pronounced instability that the patient is threatened with pain and disability whenever undue physical activity is attempted. The roentgenologic technic of Chamberlin is an aid in demonstrating the presence of these lesions According to this technic sacro-iliac joint motion is demonstrated at the symphysis pubis. Toward this end stereoscopic views of the pelvis (posterior projection) are studied for asymmetry then a view of the patient s pelvis is taken (anterior projection) with weight bearing on one lower extremity then on the other By measuring the degree of movement of the symphysis pubis in these plates the extent of sacro-iliac motion is determined (Fig 6, *A* *B* and *C*)

2 *Spondylolisthesis and spondyloschisis* Spondylolisthesis occurs when a separation or break occurs in the laminar arch thus untying" the involved vertebra and allowing it to dislocate forward on the vertebra below This break in the laminar arch may be a congenital defect or an actual fracture resulting from trauma. It is not always easy to differentiate the two types for in the former type there might have been a fibrous defect which was ruptured by a traumatic incident and in the latter the arch may have been normally intact until frac

tured by the traumatic incident. Either condition lends itself to conservative management by various methods ranging from sustained traction on the thighs with the hips in flexion to manipulation with or without anesthesia. In those types of congenital etiology the effectiveness of conservative therapy is generally not permanently sustained and operative fusion must be done. In the cases of frank fracture immobilization in plaster for six to twelve weeks following satisfactory reduction should suffice so far as corrective endeavor is concerned.

Illustration A young girl nineteen years of age dated the onset of her low back complaint to an incident two years before at which time she fell and injured her back. Since then attacks occurred at intervals of several months She found that an attack could be precipitated by leaning forward and that seemingly this could be reduced by lying down in bed. She described the pain as being in midline at the lumbosacral level. There was no radiation down the thigh but during an attack the pain radiated on either side anteriorly to the abdomen and groin. Roentgenograms disclosed a spondyloschisis and spondylolisthesis involving the fifth lumbar vertebra (Fig 7 *A* *B* *C* and *D*) A spinal fusion was performed

Group V Conditions in which manipulation is not only ineffective but harmful and therefore contraindicated

These conditions include compression fractures of the vertebrae acute arthritic processes tuberculosis syphilitic disorganization advanced rarefaction etc

Manipulative therapy is therefore of a selective type and its success depends entirely upon the correctness of the diagnosis of a low back condition. If it is tried upon all cases of low back pain irrespective of their etiology the results may range all the way from that of indifference to that of actual damage For all practical purposes the cases in which manipulative therapy produces the most effective corrective results fall in Group I Cases in Groups II and IV react in a most satisfactory manner and very often derive as much benefit as do those of Group I Cases in Group III may be afforded much relief if skillfully manipulated but because of the nature of their lesions surgical intervention is very often necessary

In Group V manipulation should never be employed The latter statement is meant to emphasize the necessity for adequate study and accurate diagnosis of low back conditions This brings us to a consideration of the etiology and pathogenesis of backache

Anatomic Aspects.—The bodies of the vertebral column are joined one to the other by means of the fibrocartilage or intervertebral disks as well as by the various ligaments that connect the body lamina and its processes with corresponding parts above and below This makes for a strong supportive column that is flexible and

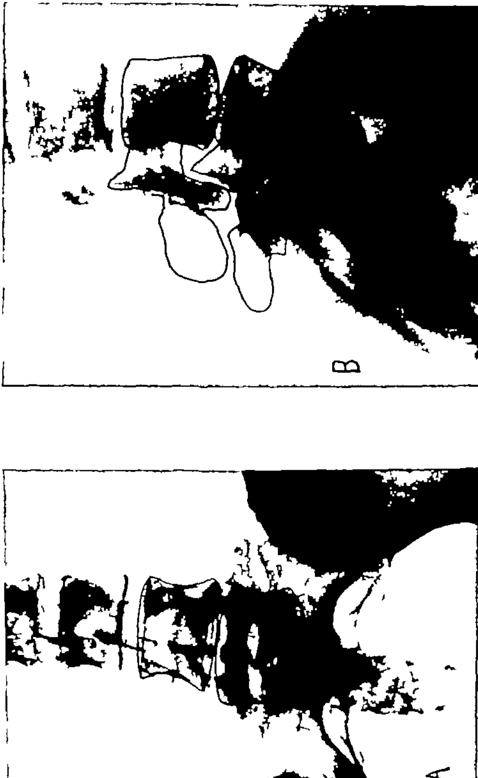

Fig. 7.—(*A*) Anteroposterior view showing a lateral shift of the fourth lumbar vertebra on the fifth (*B*) Lateral view showing the forward dislocation of the fifth lumbar vertebra on the sacrum (spondylolisthesis)

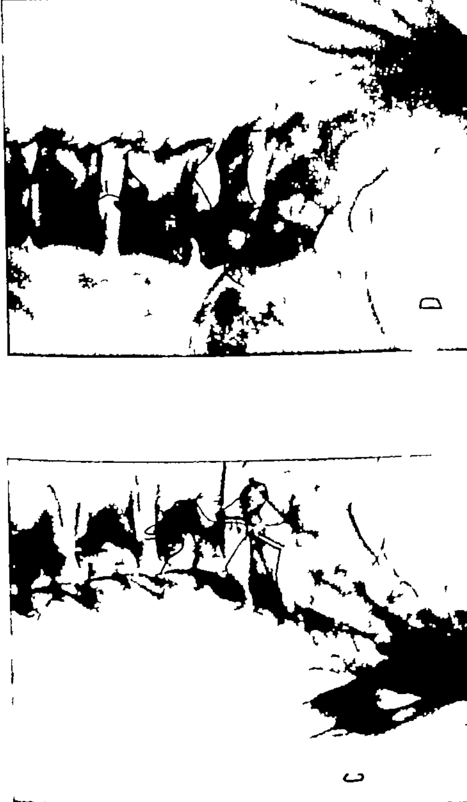

Fig. 7 (Cont.).—(C and D) Oblique view showing defects in the neural arch at the site of the fusion of lamina with the pars interarticularis (spondyloschisis)

resilient to weight bearing and movement. With the development of disease or the advancement of age, this flexibility may be modified to varying degrees of rigidity

A typical vertebra is composed of a body, from which extend posteriorly the vertebral arches to enclose a large hole called the vertebral foramen the latter containing the spinal cord the vertebral arch consists of four essential parts a right and left root of the arch or pedicle at the sides of the foramen, and a right and left lamina at the back of the foramen, various processes project from the arch the spinous process a pair of transverse processes and two articular processes—a superior and an inferior pair Their articulating surfaces are termed interlaminar facets Trouble may arise in the body because of fracture dislocation inflammatory process or neoplasm Likewise, the vertebral arch or its processes may be primarily or secondarily affected. When the vertebrae are in position on the sides between the pedicles there is a row of holes called the intervertebral foramina. A spinal nerve passes through each intervertebral foramen With alterations in the structure or mechanical function of the bony or ligamentary elements the spinal nerves may become directly involved and give rise to pain confined to the axial system or radiating to the appendicular system.

The intervertebral disk or fibrocartilage is composed of a circumferential portion the annulus fibrosus and the axial or central part—an elastic, soft, pulpy mass called the nucleus pulposus With ruptures of the posterior portion of the annulus fibrosus the nucleus pulposus may be extruded out into the vertebral canal giving rise to pressure on the cord. In the lumbar region a typical low back pain syndrome with radiation down one or both thighs may result.

The ligaments are mainly composed of the anterior longitudinal ligament which extends along the anterior surface of the bodies, the posterior longitudinal ligament extending along the posterior aspect of the bodies within the vertebral canal the interspinous ligaments which attach to adjacent spinous processes, and the supraspinous ligaments extending from spine to spine and being attached to their tips superficial to the interspinous ligaments The ligamentum flavum lately a focus of attention, extends between adjacent laminae and articular processes in the posterior part or the back of the vertebral foramen.

The vertebral column in the adult presents a forward convex curvature in the cervical region, a forward concave curvature in the thoracic region a convex forward curvature in the lumbar region, the sacrococcygeal curvature is concave downward and forward. The normal range of these curvatures is apparently an individual pattern. When however physiologic limits have been exceeded and the curves become exaggerated, pain and disability may result because of alterations in weight bearing, unequal muscle pull and dislocation of viscera.

While the pelvis is very often an important consideration in analyzing back conditions, it is not deemed necessary to stress any anatomic characteristics save to mention the lumbosacral and sacro-iliac joints. The sacro-iliac joints are easily localized in examinations by identifying the posterior superior spines and by palpating immediately below them in a line that runs downward and somewhat laterally

Deviations from the Normal Structure Which Are Productive of Pain.—CONGENITAL DEFECTS OR ANOMALIES —We have presented a sketchy yet selective review of the normal structural findings of the back. Any variations from these normal standards present at birth are classified as congenital deformities or anomalies. It can be appreciated readily that, because of the possibilities of variation a formidable list of such anomalies might be compiled So far as the vertebral bodies are concerned there may be anomalies of the body itself of the pedicles of the laminae of the intervertebral facets and of the transverse processes There may be anomalies of the ribs of the scapulae of the neck and of the lower extremities which secondarily involve the back. How significant are these conditions clinically and, more to the point how much importance should be attached to them as causative factors of backache?

This consideration should be kept in mind muscle balance is as important a factor as bone integrity in the normal alignment and mechanical efficiency of the spine The various types of muscles are paired off into opposing groups Under normal conditions opposing muscles exert an equal pull Should one group become weaker the opposite group becomes stronger exerts a greater pull and deformity results When unequal muscle pull affects the spine the weight bearing line is altered because of the resulting deformity and an actual condition of abnormal stress and strain sets in

Congenital defects in many instances exert little or no painful influence in the earlier years Probably that is one of the reasons why they are sometimes woefully neglected until later years at which time conservative efforts or even surgery may offer little in the way of permanent respite. While in the earlier stages congenital defects may not give rise to symptoms nevertheless the deformity is always present, is likely to increase with age and in most instances will become a source of pain and disability in the more exacting routines of adult life. Let us consider a few examples.

1 *Torticollis*—The term implies a torsion of the neck and one thinks immediately of a shortening or contracture of the sternomastoid muscle usually unilateral but occasionally bilateral There are many cases that are not outstandingly obvious even to the experienced One must look carefully for the characteristic features a rotated tilted and displaced head with facial asymmetry a shortened sternomastoid muscle and a lateral curvature of the spine. While the deformity of torticollis usually arises from a defect of the muscle roentgenograms

of the cervical vertebrae are taken in all cases to determine the presence of any anomaly of the bones We are concerned here not so much with types of different etiology as we are with the fact that such deformity of whatever cause is usually accompanied by a secondary curvature of the spine which if allowed to go on uncorrected to adult life may produce a painful back. The rational therapy would be first, adequate correction of the neck deformity and then, correction of the lateral curvature of the spine

2 *Sprengel's Deformity* —This is a congenital elevation of the scapula usually unilateral, but occasionally bilateral The pathologic findings include the following shortening of the scapula so that the transverse diameter is greater than the vertical a hooking over of the upper part forward bony cartilaginous or fibrous bands connecting the scapula to the vertebrae, and coexisting defects of ribs, vertebrae and muscles. As was the case with torticollis, scoliosis occurs probably in over half of these cases

3 *Congenital Abnormalities Involving the Lumbosacral Joint* —The lumbosacral joint which joins the lower spine to the pelvis is rather freely movable in the directions of flexion and extension. The former movement is accomplished by means of a change in the intervertebral disk as well as by a slipping upward of the articulating process of the fifth lumbar vertebra on the opposing articulating process of the sacrum. In these movements the stability of the joint is maintained by the integrity of these articulating processes and facets and their supporting ligaments. It is additionally reinforced by the iliolumbar ligaments which pass from the body and transverse processes of the fifth lumbar to the iliac crests

Theoretically if flexion were carried too far, the articular processes of the fifth lumbar might slip entirely off those of the sacrum allowing the body of the fifth to slide forward on the sacrum in the abnormal position known as spondylolisthesis (Fig 7) Actually in the presence of normal anatomic structures this is not likely except with the intervention of fracture such a condition in variable degree does occur, however in the presence of congenital defects either osseous or ligamentary

The most common congenital anomalies involving this area have been classified by Dickson as follows

1 Increased angle of the lumbosacral junction.
2 Defective articulation between the fifth lumbar and sacrum.
3 Sacralization of the fifth lumbar vertebra.
4. Spina bifida occulta of the first sacral segment.
5 Spinal clefts (Fig. 7)

In cases of low back pain of indeterminate etiology and when we discuss the lumbosacral region we usually have this disability in mind lateral roentgenographic views of the spine should be studied for evidence of increased angulation of the joint. When this is marked

there is as well as a disturbance of the interlaminar facets a con striction of the lumbosacral foramina which can cause root pressure of the nerve as it makes its exit and can give rise to debilitating pain of a radiating type

Sacralization of a transverse process of the fifth lumbar ver tebra may be clearly demonstrated in roentgenograms and must always be considered a possible factor in painful conditions of the lower back. In lateral clefts there is a failure of the lateral masses of the fifth lumbar to unite This means the body is joined to the lateral masses by fibrous tissue which under stress and strain may gradually yield with the production of spondylolisthesis Other anomalies in volving the lower extremities have to do with shortening on the affected side with subsequent lateral tilt of the pelvis and the produc tion of a secondary scoliosis

Poor Body Mechanics —The normal anatomic curves of the spine have been reviewed and some of the factors which produced altera tions in them were pointed out as congenital defects Changes in spinal curvature may arise in a previously normal back because of unequal muscle pull resulting from poor carriage or bad posture These considerations come under the heading of bad body mechanics and are particularly troublesome at times because they give rise to a sort of vicious circle in which fatigue gives rise to greater deformity which in turn causes greater fatigue This particular disability is prev alent among all age groups and a source of clinical symptomatology more often than one would surmise In children it may manifest itself as lowered stamina and the inability to carry on the ordinary activities of the healthy child In the adult pain as well as fatigue is the fre- quent complaint and is referred to either of several sites the mid dorsal region between the scapulae or the low lumbar (lumbosacral) level.

In surveying the patient, one might begin at the feet and progress upward. Of the feet the following notations are made integrity of the longitudinal arch and metatarsal area presence and placement of callosities presence and degree of toe deformities. (A chronically painful foot may cause a partial shift of weight bearing to the opposite extremity with unilateral strain transmitted to the pelvis and low back.)

Examination of the ankles in the weight bearing position will im mediately disclose any degree of pronation—a deformity which should not be overlooked or disregarded If it is quite marked the tibia is rotated internally causing internal rotation of the knee joint and femur This torsion of the knee joint subjects its ligaments and asso- ciated muscles to strain which eventually manifests itself as inter mittent or constant pain Internal rotation of the femur over an extended period of time produces a concomitant stretching of the ex ternal rotators of the thigh including the piriformis muscle Because

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ARTHRITIS —Under inflammatory conditions a word might be inserted here about the arthritides The types of immediate interest are hypertrophic spondylitis and infectious spondylitis In the former there is an attendant involvement of the joints external to the spine such as the knees fingers (Heberden s nodes) etc The latter infectious spondylitis is known by many terms deforming arthritis degenerative arthritis poker spine, spondylose rhizomélique and when the shoulders and hips also are involved Marie-Strumpell s disease. In the hypertrophic type, the roentgenogram shows a proliferation about the margins of the joints such as lipping or a massive projection of bone about the margins of the articular surfaces The joint space is diminished from destruction of the cartilages and the joint surfaces become irregular and distorted Ankylosis seldom occurs Pain may be a constant symptom may occur only after periods of rest or may be activated by trauma Many times hypertrophic changes are seen in the spines of patients who have no backache complaint at all. In the infectious or Marie-Strümpell type the roentgenogram shows an absorption of the intervertebral disks and bony outgrowths fusing and connecting one vetebra with the other The spine becomes rigid throughout its entire length In the dorsal spine with involvement of the costovertebral joints the ribs become fixed to the vertebrae and sternum thus producing an immobile thorax. In the earlier stages there is some pain either in the back or radiating to the buttock and lower extremity In the later stages when ankylosis becomes more or less generalized the obliteration of movement releases the patient from pain The picture of a patient with a spine of poker stiffness and associated kyphos and with ankylosis of the shoulders and hips is one not easily confused with any other pathologic condition.

MALIGNANCY —In younger people as well as those in the later decades of life the complaint of backache may originate from a malig

the sciatic nerve emerges immediately beneath this muscle, stretching of the latter over an extended period of time may give rise to an irritation of the nerve. If pronation of the ankle is severe and more marked on one side, unilateral strain producing a low back syndrome with sciatic irritation may result.

Examination of the patient in the lateral view discloses abnormal or exaggerated spinal curvatures If the patient presents a sweeping lordosis or definite sway back, he is entitled to the complaint of low back pain. The picture is a characteristic one. With the marked lordosis the pelvis is elevated in back and held there by contracted sacrospinalis muscles, it is dropped downward and backward in front and so held by the shortened and contracted tensor fasciae latae. Because it has been stretched and weakened by the pelvis dropping downward, the lower abdominal wall is relaxed and pendulous The marked anterior convexity of the lumbar curve produces a compensatory marked posterior convexity of the dorsal or thoracic curve in order to maintain balance This produces the round back and flattened chest. In consequence of the latter, the head inclines forward and downward producing a third area of pain at the base of the neck at the level of the seventh cervical vertebra. (See Fig 24 *A* and *B*)

It has been observed that a marked pronation of the ankle on one side may give rise to unilateral back strain So also, the shortening of one lower extremity however caused may, because of the lateral tilt to the pelvis which it produces, give rise to a low back pain syndrome as well as a postural scoliosis.

There is a type of round back seen in adolescents which is not purely postural This particular type of round back occurs during the period of growth and results from vertebral osteochondritis The roentgenograms serve to differentiate it from tuberculosis which it may mimic clinically, and from Kümmell s disease. The latter entity follows trauma to the spine and will be discussed under that heading

There is no need to discuss in any detail here the deformity of lateral curvature or scoliosis Suffice it to say that there are two types —postural and structural The postural type is readily amenable to such treatment as posture correction and corrective exercises. The structural type remains a problem of therapy so far as conservative efforts are concerned and thus far spinal fusion alone seems to yield the most satisfactory result in advanced cases. What seems to be most important is not only the recognition of these types but their earliest possible correction. If the patient to be examined leans forward flexing the spine in the standing position, the elevation of one side of the back resulting from the oblique deformity of the thorax is accentuated In the postural type there is a general curve convex to the left, the left shoulder is elevated the right side of the shoulder girdle is carried back and the left side forward and when the patient bends forward the right side of the back may be slightly higher than the left.

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nant growth in the spine. While such a neoplastic process may be of a primary type in most instances it is the result of metastatic or secondary implantation As the growth progresses the same sequelae that are met with in tuberculosis may occur destruction of the bone with collapse of the vertebral body deformity ranging from a small kyphos to curvature or angulation of the spine and in extreme conditions cord pressure symptoms The diagnosis is based upon a careful history to detect any primary growth studied appraisal of the presence of constitutional symptoms and roentgenographic examination.

Trauma.—A carefully taken history is always the first step in the establishment of a diagnosis Ruling out many conditions immediately and suggesting others as possibilities it points the direction in which investigation is to be carried out. If for example, the patient who complains of backache dates the onset to the time of a traumatic incident and declares that previous to the accident his back had never bothered him, one begins to think in terms of fracture dislocation or sprain. The nature and extent of the trauma should be carefully investigated. No matter how slight, its importance should not be minimized until due examination is carried out As an instance, falling in the sitting position even from no great distance can produce a compression fracture of a vertebral body Forced flexion of the spine might produce a rupture of the intervertebral disk and the subsequent movement of extending the spine may cause an extrusion of the nucleus pulposus into the vertebral canal. Trauma to the lumbosacral region may fracture the vertebral arch and produce a spondylolisthesis, and so on Compression fractures of the vertebral bodies are lesions frequently overlooked. The chronic and debilitating backaches that result are sometimes so resistant to all conservative treatments that spinal fusion remains the only alternative—a rather drastic finale to a lesion which can be corrected immediately following early recognition. Along with this group of sometimes obscure lesions belong fractures of the transverse processes

There is another clinical entity which follows spinal injury known as Kümmell s disease The roentgenogram discloses a rarefying osteitis of one or more vertebrae some of which may show wedge deformities The lesion may occur weeks or months after the spinal injury at least the symptoms do not become manifest until after such periods of time. The patient begins to complain of pain at the involved site and a developing kyphos appears. It is generally seen in young adults and usually involves the dorsal vertebrae.

Neurologic Conditions —In the presence of low back pain with sciatic irritation the possibility of a nucleus pulposus extrusion (Figs 3 and 4) should be kept in mind throughout the course of the investigation Neurologic changes must be carefully looked for And even in their absence if the patient does not respond satisfactorily to con

servative treatment, a lumbar puncture should be done to determine the presence of any block an elevation of total protein or the presence or absence of pathologic cell types When the total protein is elevated above 40 mg per 100 cc. the injection of lipiodol or air into the canal for roentgenographic visualization is indicated. Any one of three conditions—ruptured nucleus pulposus spinal cord tumor and hypertrophied ligamentum flavum—is investigated in this manner and lipiodol visualization serves to diagnose such a block when the roentgenograms are interpreted

Methods of Investigation —In prosecuting any investigation it is well *to remember that pain in the back as elsewhere may be of* an intrinsic sort, that is originating in the affected area or it may be of an extrinsic sort, that is originating in a place other than and *apart from the area apparently involved This latter type is recog*nized as being referred pain or in relation to the matter under con*sideration as symptomatic backache By being so mindful one is* less apt to be misled because of a diseased gallbladder or coronary disease or prostatitis or retroperitoneal lymph gland involvement and so on.

The manner of further procedure would be first to listen to the *patient (interpolating his account with pertinent questions) then to* look and finally to complete the assembling of facts by means of whatever laboratory work is indicated Listening to the patient in order to acquire pointed facts about the particular backache involves the acquisition of a complete and detailed history One would know the time and circumstances attending the onset of pain the presence or absence of trauma and its exact relation to the occurrence of the lesion the order in which the symptoms were observed how the patient stands sits and rests in bed. If the illness has progressed in attacks the history of a typical attack should be obtained—onset duration, and the frequency of occurrence the site of the pain and whether or not it radiates and associated symptoms such as chills fever list or scoliosis etc. the relation of these attacks to any activity of the patient or to such factors as diet, local infections etc. whether the patient is improving or becoming worse previous treatment and previous medication Likewise you would want to know the type of bed the patient sleeps upon—whether the mattress is an inner spring type or solid felt etc. the kind of bedsprings whether or not the bed sags under weight. Along the same lines the upholstery of the patient s motor car is investigated as well as the routine use of over stuffed upholstered furniture As important in this history is a detailed family account and past history including habits environmental and occupational influences and most important, regional survey with cardiac, respiratory gastro-intestinal and genito-urinary inquiries

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This physical examination should include a detailed study of the back For this purpose the patient completely removes his clothes.

Female patients wear a brassière and shorts The patient is studied in various posture attitudes and selected active and passive motions are carried out. In other words the mechanical integrity of his back is studied from the standpoints of weight bearing non weight bearing, muscular relaxation and movement. Very often a lesion is localized not only because of the emanation of pain but also because of the muscular rigidity or spasm to be noted about the affected region.

1 *Inspection* —The standing posture is studied from the posterior lateral and anterior views The posterior view discloses any list or lateral curvature of the spine. This list may be away from the side complained of (contralateral), toward the side complained of (homolateral) or in rare instances it may be of an alternating type. Associated with this list is a contraction of the sacrospinalis muscles, more marked on one side usually, and occasionally to a degree of painful spasticity Contraction of the gluteal muscles as well as the ham strings may be quite definite. These latter phenomena may be more readily detected by comparing the gluteal fold levels, and by noting whether or not the patient stands with the knee on the painful side flexed. Associated with the list is an inequality of the shoulder levels one resting higher than the other Comparing the levels of the posterior superior spines assists in detecting the presence of a lateral tilt to the pelvis. The posterior aspect of the patient likewise may reveal such details as a shortening of the back and increased prominence of the buttocks and iliac crests—changes which are seen in some cases of spondylolisthesis

The lateral view more effectively discloses postural defects Such conditions as forward inclination of the head flat chest round back flaring scapulae lordosis relaxed lower abdominal wall, anterior pelvic tilt, etc., can be noted at a glance.

From the anterior view one confirms the presence of a list or of a scoliosis Any oblique deformity of the thorax is usually more prominent from this aspect. Lateral pelvic tilt may be checked again by comparing the levels of the anterior superior spines Internal rotation of the femora and pronation of the feet are defects looked for at this time.

Leg Measurements If there is present a lateral tilt to the pelvis, then the lower extremities must be measured in order to determine their comparative length Each extremity is measured first from the anterior superior spine to the internal malleolus (actual length) and then from the umbilicus to the internal malleolus (apparent length) Care should be taken that the patient is lying straight—that is with the longitudinal line of the extremities at right angles to the transverse line of the pelvis The circumferential measurements of both thighs and legs are determined at this time as a part of the neurologic examination.

2 *Palpation* —By means of palpation one is often able definitely to localize the pain as well as to detect tumor masses and muscle

spasm. It is well to carry out this procedure with the patient standing and his back flexed about 20 degrees The interspinous and supra spinous ligaments are palpated throughout the length of the spine as are also the spinous processes Any undue prominence of the latter or tenderness of the former is noted. The paravertebral gluteal and piriformis muscles in turn are palpated. The lumbosacral and sacro-iliac joints are quite superficial and readily accessible to direct palpa tion. The following ligamentary structures also are examined for tenderness the iliolumbar sacro-ischial sacrotuberous and the tensor fascia lata. In lumbosacrals the tenderness is localized to the mid line when interspinous ligaments are involved and lateral to the vertebral bodies where there is strain of the iliolumbar ligaments With sprain of the ligamentum sacrotuberosum and sacrospinosum tender ness extends from the lateral borders of the sacrum to the tuberosity of the ischium.

3 *Active Movements* —Next, the vertebral column is closely studied in its various movements Such factors as the occurrence of pain muscle spasm and limitation of motion are noted There is first in the standing position forward flexion of the spine then hyperextension, then lateral bending to right and to left followed by rotary torsion to right and to left. In the standing position when the patient attempts flexion of the spine in a lumbosacral condition the lumbar spine will be noted to be rigid most action taking place at the hip joints In sacro-iliacs the lumbar spine will be quite flexible and bending takes place until the hamstrings become taut, then the knee bends on the affected side. In hyperextension the lumbosacral type remains rigid bending backward by bending the knees In the sacro-iliac hyperextension is free. In lateral flexion the lumbar region is rigid in the lumbosacral type and motion is better away from the painful side In acute in flammatory sacro-iliacs motion is generally more limited toward the side affected while in sacro-iliac strain the opposite is true

The patient is changed from the standing to the sitting position and in such position he bends forward again flexing his spine In this movement a list to one or other direction may be noted which was not present in the standing position—an indication of the existence of muscle spasm possibly not previously detected The procedure is also useful as a comparison with the reaction of the patient during the similar movement while standing When pain is apparently emanating from the sacro-iliac region patients are able to flex the spine quite well in the sitting position while in the standing position such a motion is inhibited by pain and muscle spasm of the hamstrings The tension on these muscles is transmitted to the ischial tuberosities their points of origin and from there to the sacro-iliac joints With the pull of the hamstrings eliminated by the sitting position the activity of the spinal vertebrae and lumbosacral joint is studied to better advantage.

From the sitting position the patient is changed to the supine posi tion and his ability at straight leg raising on both the right and left

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Diagnosis.—By summing up the high lights of the preceding discussion on methods of investigation we have the accumulated material by means of which we arrive at a diagnosis and determine the mode of therapy

I. Detailed History
- 1 Circumstances of onset—gradual, abrupt.
  Order of appearance of symptoms.
- 3. Type, character distribution of pain.
- 4. Presence or absence of trauma.
- 5 Posture f patient in normal sitting, standing, bed rest
- 6 If recurrent attacks.
  - a. History of typical attack.
  - b Relationship to activity diet local infections.
- 7 Previous treatment in detail.
- 8. Environmental and occupational influences.
- 9. Regional survey
  - a. Cardiac
  - b. Respiratory
  - c. Gastro-intestinal
  - d. Genito-urinary
  - e. Neuromuscular

II Physical Examinatio
- 1. General physical examination.
- 2 Orthopedic (detailed back) examination.
  - A. Inspection (standing posture)

Posterior view	*List*	*Scoliosis* {Dorsal / Lumbar}
	Shoulder levels	
	Sacrospinalis	
	Position of posteri superio spines	
	Gluteal crease levels	
Lateral view	Chest	Back {Round / Lordosis}
Anterior view	Abdomen	
	Rotation of shoulders	
	Rotation f pelvis	
	Position of anterior superior spines	
	Rotation of femora	
	Pronation of feet	

Leg measurements

Actual (anterior superior spine to internal malleolus)	right	left	Apparent (umbilicus to interio mal leolus)	right	left
Calf	right	left	Thigh	right	left

sides is checked Straight leg raising (raising first one and then the other leg without bending knee) is usually painful and inhibited to a fraction of its range on the side down which the low back pain is radiating. In some cases, straight leg raising on the opposite side causes pain on the affected side. To consider this test indicative of a sacro-iliac lesion, any motion of the lumbosacral joint must be prevented during its performance.

4. *Passive Movements* —Under this heading are included the various signs or tests used in localizing lesions of the back. No single test can be relied upon to localize or diagnose the lesion The following special tests are carried out unless otherwise indicated, when the patient is in the lying (supine) position

(a) Laguère s sign forcing the leg in flexion abduction and outward rotation elicits pain in the sacro-iliac joint.

(b) Goldthwait s sign tension of the hamstrings elicits pain in sacro-iliac joint (straight leg raising test)

(c) Gaenslen's sign hyperextension of hip elicits pain in the sacro-iliac joint. Immobilized by flexion of other thigh and knee

(d) Ober's adduction test the patient is placed on his side with lower hip and knee flexed. The uppermost extremity with the knee flexed is extended and abducted at the hip joint. With the knee flexed the thigh is allowed to adduct. If the fascia is taut, adduction is limited and the fascia stands out as a definite band

(e) Ely's sign (described by Ober as indicative of fascia lata contracture) patient lying prone on table while examiner flexes leg on thigh As flexion takes place the pelvis rises from the table.

(f) Compression of the iliac crests and pressure over the pubis are also routinely employed.

5 *Neurologic Examination* —At least a cursory neurologic examination is done in every instance. The patellar reflexes are checked as well as the ankle jerks It is stated that about 50 per cent of the cases of ruptured nucleus pulposus showed absent ankle jerk. In a small percentage there is urinary and fecal incontinence A considerable number of these cases present sensory changes—either saddle anesthesia or involved areas on posterior thigh lateral calf and lateral border of the foot. If any of these findings are present, lumbar puncture is done. Analysis of the spinal fluid determines the further step of lipiodol injection and roentgenographic study

6 *Roentgenologic Examination* —Poor x-ray plates are a waste of time and money In various conditions giving rise to backache, plates that simply show the shadow of the bones are useless. There must be clear sharp bone detail or else even an approximation to an accurate diagnosis may not be possible. At least two views the anteroposterior and lateral are necessary in studying spine conditions. In particular instances not only these but opposite oblique views are necessary in order to check the integrity of the interlaminar facets In the examina

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Posterior view List — Scoliosis {Dorsal, Lumbar}
Shoulder levels
Sacrospinalis
Position of posterior superior spines
Gluteal crease levels

Lateral view Chest — Back {Round, Lordosis}

Anterior view Abdomen
Rotation of shoulders
Rotation of pelvis
Position of anterior superior spines
Rotation of femora
Pronation of feet

Leg measurements

Actual (anterior superior spine to internal malleolus)	right	left	Apparent (umbilicus to interior malleolus)	right	left
Calf	right	left	Thigh	right	left

B Palpation
Palpable tenderness

Iliolumbar	right	left	Lumbosacral	right	left
Sacro-iliac	right	left	Sacrotuberous	right	left
Piriformis	right	left	Sciatic nerve	right	left
Sacro-ischial	right	left	Interspinous ligaments	right	left

C. Active Movements
Standing
Forward flexion
Hyperextension Lateral left Lateral right
Rotary left Rotary right
Sitting
Forward flexion
Supine
Straight leg right left

D Passive Movements (Special Tests)
Pressure on iliac crests and symphysis pubis.
Laguère's Gaenslen's Ely's right left
Ober's abduction right left

E. Neurologic
Knee jerks Ankle jerks Babinski Saddle anesthesia

III. Significant Laboratory Work Blood picture sedimentation rate, Wassermann, lumbar puncture, etc.

IV X Ray Anteroposterio lateral and oblique views of section of spine under investigation. Lipiodol visualization when indicated.

Manipulation.—Sprains involving joints vary in severity from marked stretching to actual tearing of capsule and ligaments, with certain degrees of subluxation. In order to be successful, therefore the therapy for such conditions must adequately anticipate the extent of the pathology In brief the accepted treatment of sprain is rest by means of immobilization local applications for accelerating circulatory response, and sufficient time to allow the injured tissue to heal. Some types of sprain for instance that of the ankle do well on this regimen Given a sprain involving a deeper joint, however, with marked muscle spasm and some degree of deformity the carrying out of this routine of immediate immobilization and prolonged rest may afford little correction or relief Rather more logically in such cases one would be prone to manipulate gently the involved joint, in order to correct whatever degree of malalignment or subluxation may have occurred incident to the tearing or stretching of the ligaments or capsule In this manner the normal relations of the joint are restored the torn soft tissues are more correctly approximated and the muscle spasm is more effectively and permanently allayed.

The technic herein described used without anesthesia and evolved over a period of nine years has been successfully used in several hundred cases.

Contraindications —In discussing the subject of contraindications one presupposes satisfactory relaxation of the patient and a manipulative technic that is neither rough nor unduly forceful. Strength should not be mistaken for skill If these conditions do not

obtain it is quite likely that undesirable and even dangerous results may ensue. Patients with chronic low back pain should never be manipulated until they are adequately examined and the general condition fully appraised by means of a complete investigation In this way such definite contraindications as fracture neoplasm tuberculosis suppurative arthritis, advanced rarefaction secondary to hyperparathyroidism, etc. are ruled out and avoided Uncompensated cardiac cases of course constitute a definite risk. Patients with inguinal hernia may be handled carefully and without undue danger

Preparation of Patient —The manipulation is carried out with the patient lying not on a table but on the floor In order to insure adequate purchase in gripping the shoulder ilium etc, the patient is completely unclothed. Likewise, to prevent the mat from slipping on the floor a sponge rubber base is first laid down and upon this a leather mat and a cloth mat are placed in turn. Very often these patients are in such acute pain that standing and moving are extremely difficult. For these reasons they are taught how to get down to the floor properly thereby saving themselves further muscle spasm or strain. By bending the knee on the well side and resting both hands on it, they gradually bring the affected knee down to the floor followed then by the good knee Once down upon both knees they then lean forward on their hands in the knee-hand position. By flexing the elbow and bringing the trunk forward the knees are gradually extended the trunk is gently lowered to the floor and the prone position is thus assumed

A survey of the patient in this prone position makes quite evident most of the deformities observed in the weight bearing erect attitude —the list (whether homolateral or contralateral) the spastic sacrospinalis muscles and the very evident general rigidity of the patient. The sites of tenderness—whether in the lumbosacral iliolumbar or sacro-iliac regions or in the gluteal or piriformis muscles or in the ligaments—are still quite positive.

For this reason massage of the gluteal muscles (Fig 8) is begun carefully and gently the patient meanwhile being induced to relax as completely as possible When the pelvis begins to roll more easily from side to side with the gentle massage the deeper kneading which eventually includes the areas of tenderness and pain is begun From the pelvis the course of massage proceeds to the paravertebral areas and finally to the mid thoracic region so that the shoulder girdles are likewise brought into a state of as complete relaxation as is possible This procedure is eminently successful in securing satisfactory preliminary relaxation in most cases. The greater part of its success depends upon the intelligent co-operation of the patient since such relaxation at this time is largely self induced However during the course of the manipulation it will be noted that a more complete state of relaxation very definitely results from particular maneuvers, and

B. Palpation
  Palpable tenderness

Iliolumbar	right	left	Lumbosacral.	right	left
Sacro-iliac	right	left	Sacrotuberous	right	left
Piriformis	right	left	Sciatic nerve	right	left
Sacro-ischial.	right	left	Interspinous ligaments	right	left

C. Active Movements
  Standing
    Forward flexion
    Hyperextension Lateral left Lateral right
    Rotary left Rotary right
  Sitting
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  Supine
    Straight leg right left

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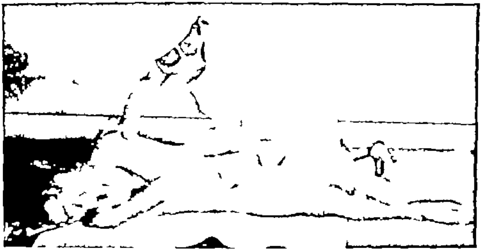


Fig 10.—Maneuver 2 Reverse of Maneuver (Extends left sacro-iliac joint and stretches anterior sacro-iliac ligament also rotates lumbosacral joint in opposite direction to Maneuver 1)

perior spine and holds the left shoulder with his right hand He then executes a rotary or torsion movement bringing the patient s shoulder backward and at the same time thrusting the ilium forward and downward (Fig 9)

Discussion—An important phase of this particular movement is a sudden and prolonged downward and forward thrust to the ilium which very often results in a snapping sound at times relatively prolonged, which simulates the tearing apart of sheets of flypaper This movement tends to shift the left ilium forward or to flex it on the sacrum separating the posterior margins of the left sacro-iliac joint and therefore tensing and stretching especially the left posterior sacro-iliac ligament. The left iliolumbar ligament likewise is stretched because of the opposing movements of trunk and pelvis This latter movement is responsible for a simultaneous rotary movement of the interlaminar joints of the lower thoracic and all of the lumbar vertebrae as well as of the lumbosacral joint

Maneuver 2—The patient maintains the position as in Maneuver 1 The manipulator then reverses the movement bringing the shoulder forward and thrusting the left ilium backward and upward (Fig 10)

Discussion—This maneuver has a tendency to separate the anterior margins of the left sacro-iliac joint and to stretch therefore the left anterior sacro-iliac ligaments. The rotation and mobilization of the lower thoracic and lumbar interlaminar joints and of the lumbosacral joint are now in the opposite direction Relaxation of the sacrospinalis group very often occurs at this time with beginning correction of the list.

Résumé—In these two maneuvers the left sacro-iliac joint has been primarily mobilized with secondary mobilization of the lower thoracic

FIG. 8.—Demonstrating the deep kneading massage of the gluteal muscles.

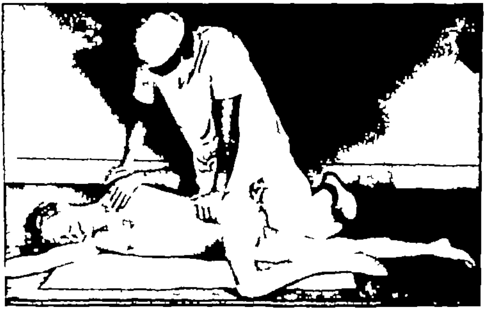
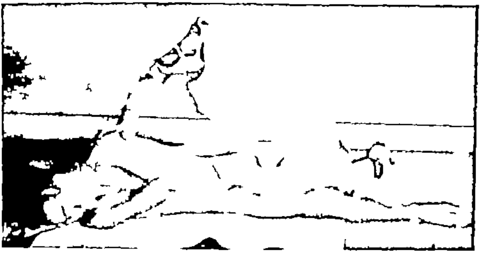


FIG. 9.—Showing the position for Maneuver 1 of the actual manipulation. The ilium is thrust forward and downward the shoulder is rotated backward. (Flexes left sacro-iliac joint and *stretches posterior sacro-iliac ligament. Some rotary movement to lumbo-*sacral joint.)

it is undoubtedly enhanced by the disappearance of the painful spasm of the affected sacrospinalis muscles

MANEUVER 1 —The patient is taken from the prone position following deep muscle massage and is placed on his right side The right knee and hip are extended fully The left knee and hip are flexed The left hand is placed over the left pectoral region This position is arranged by the manipulator Next the *manipulator with his* left hand grasps the left ilium firmly in the region of the anterior su



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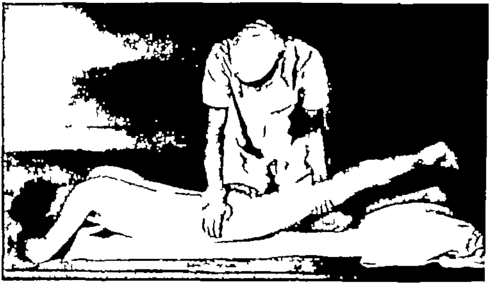


Fig. 11 —Maneuver 5 Hyperextension of thighs first with the fulcrum on the ilium second, with the *fulcrum on the sacrum In many cases, the fulcrum on the sacrum* creates much more pain than when it is on the ilium. (Primarily stretches iliotibial bands secondarily rotates sacro-iliac joints clockwise on sacrum.)

lumbar and lumbosacral interlaminar joints and of the lumbosacral joint.

Maneuvers 3 and 4 —The position of the patient is now reversed He is taken from the attitude of resting on his right side and placed on his left side The left knee and hip are extended fully, and the right knee and hip are flexed. The right hand is placed over the right pectoral region The manipulator executes the torsion or rotary movements already described and then follows with its reverse

Discussion —These maneuvers tend to separate the anterior and posterior margins of the right sacro-iliac joint, thereby stretching the associated anterior and posterior sacro-iliac ligaments The rotary movement of the lower thoracic lumbar and lumbosacral inter laminar articulations is here reversed and the iliolumbar ligament and the sacrospinalis on this side are stretched

Résumé —Maneuvers 3 and 4 primarily mobilize the right sacro-iliac joint with secondary mobilization of the lower thoracic, lumbar and lumbosacral interlaminar articulations in a direction the reverse of that obtained in Maneuvers 1 and 2

Maneuver 5 —The patient assumes the prone position. The manipulator then places his right hand forcefully over the left gluteus maximus being careful not to bridge the sacro-iliac joint (Fig 11) He then hyperextends the patient s left thigh with his left hand (care being taken that the knee is fully extended)

Discussion —This usually produces severe pain on the involved side especially if there is a contracted tensor fasciae latae present. At times

the response is more painful if the manipulator's right hand pre down on the sacrum only while the leg is being hyperextended 7 is apparently the result of increased leverage on the sacro-iliac jo

MANEUVER 6 —Similar maneuvers are carried out on the oppo thigh

Résumé —Maneuvers 5 and 6 are primarily effective in the dir stretching of a contracted tensor fasciae latae as well as in the rota mobilization of the sacro-iliac joint. Secondarily they serve to stret contracted flexor muscles of the hip

MANEUVER 7 —This maneuver is one in which the weight of tl patient s trunk is used opposite the weight of the patient s legs i bring about flexion of the lower lumbar spine and finally of the hip With the patient lying prone the manipulator stands directly over th patient s pelvis (to protect his own back from strain) grasps the an terior superior spines and with the patient as fully relaxed as possibl raises the patient from the floor causing him literally to fold up' While maintaining this position the operator rotates the patient pelvis first to the left and then to the right If the patient s weight i too great for the manipulator this same procedure is carried out using a belt, so that two manipulators perform the same movements of flexion and rotation as described (Fig. 12 A and B)

Discussion —This maneuver primarily mobilizes the lumbosacral joint and the interlaminar articulations first by flexion and then by opposing rotary movements. It is especially painful in lumbosacral involvements although pain is occasionally complained of in cases of sacro-iliac involvement. Secondarily the maneuver stretches the contracted sacrospinalis muscles.

MANEUVER 8 —The patient is in the prone position The manipu lator takes hold of the patient s feet and raises up the lower extremi ties wheelbarrow fashion hyperextending the lower thoracic, lumbar and lumbosacral interlaminar joints (Fig 13) Next hyperextension being maintained first one and then the other thigh is dropped so as to rotate the pelvis also (Fig 14) The legs are also carried from left to right, so as to describe an arc in relation to the trunk. This has a tendency to efface the list by mobilizing the lower thoracic and lum bar spine in the lateral directions.

Discussion —Hyperextension of the lumbosacral joints is primarily intended although the maneuver rotates the ilium forward on the sacrum and tends to give clockwise rotation to the sacro-iliac joints Lumbosacral lesions which on roentgenologic analysis show a decrease in the intervertebral space with possibly marked angulation of sacrum on the lumbar spine and with constriction of the lumbosacral foramina are not submitted to this particular maneuver

MANEUVER 9 —Passive straight leg raising according to the Baer technic of flexing the hip joint with the knee fully extended is car

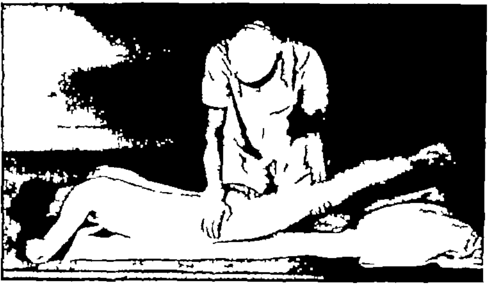


FIG. 11 —Maneuver 5 Hyperextension of thighs first with the fulcrum on the ilium second, with the fulcrum on the sacrum. In many cases, the fulcrum on the sacrum creates much more pain than when it is on the ilium. (Primarily stretches iliotibial bands; secondarily rotates sacro-iliac joints clockwise on sacrum.)

lumbar and lumbosacral interlaminar joints and of the lumbosacral joint

MANEUVERS 3 AND 4.—The position of the patient is now reversed. He is taken from the attitude of resting on his right side and placed on his left side. The left knee and hip are extended fully and the right knee and hip are flexed The right hand is placed over the right pectoral region The manipulator executes the torsion or rotary movements already described and then follows with its reverse

Discussion —These maneuvers tend to separate the anterior and posterior margins of the right sacro-iliac joint, thereby stretching the associated anterior and posterior sacro-iliac ligaments The rotary movement of the lower thoracic lumbar and lumbosacral interlaminar articulations is here reversed, and the iliolumbar ligament and the sacrospinalis on this side are stretched

Résumé —Maneuvers 3 and 4 primarily mobilize the right sacro-iliac joint with secondary mobilization of the lower thoracic, lumbar and lumbosacral interlaminar articulations in a direction the reverse of that obtained in Maneuvers 1 and 2

MANEUVER 5 —The patient assumes the prone position The manipulator then places his right hand forcefully over the left gluteus maximus being careful not to bridge the sacro-iliac joint (Fig. 11) He then hyperextends the patient's left thigh with his left hand (care being taken that the knee is fully extended)

Discussion —This usually produces severe pain on the involved side especially if there is a contracted tensor fasciae latae present. At times

the response is more painful if the manipulator s right hand pres. down on the sacrum only while the leg is being hyperextended Tl is apparently the result of increased leverage on the sacro-iliac jou

Maneuver 6 —Similar maneuvers are carried out on the opposi thigh

Résumé —Maneuvers 5 and 6 are primarily effective in the dire stretching of a contracted tensor fasciae latae as well as in the rota mobilization of the sacro-iliac joint Secondarily they serve to stretc contracted flexor muscles of the hip

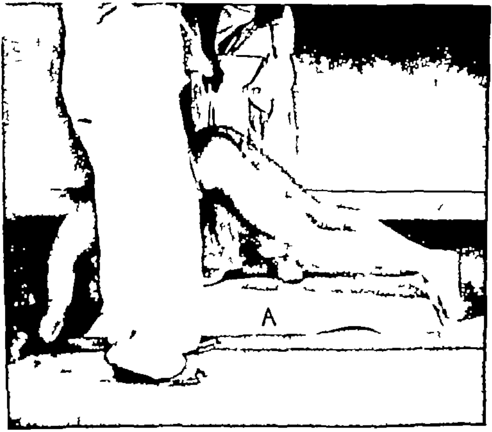
Maneuver 7 —This maneuver is one in which the weight of th patient s trunk is used opposite the weight of the patient s legs t bring about flexion of the lower lumbar spine and finally of the hips With the patient lying prone, the manipulator stands directly over th patient s pelvis (to protect his own back from strain) grasps the an terior superior spines and with the patient as fully relaxed as possibl raises the patient from the floor causing him literally to 'fold up While maintaining this position, the operator rotates the patient s pelvis first to the left and then to the right If the patient s weight is too great for the manipulator this same procedure is carried out using a belt so that two manipulators perform the same movements of flexion and rotation as described (Fig 12 A and B)

Discussion —This maneuver primarily mobilizes the lumbosacral joint and the interlaminar articulations first by flexion and then by opposing rotary movements It is especially painful in lumbosacral involvements although pain is occasionally complained of in cases of sacro-iliac involvement. Secondarily the maneuver stretches the contracted sacrospinalis muscles

Maneuver 8 —The patient is in the prone position The manipu lator takes hold of the patient s feet and raises up the lower extremi ties wheelbarrow fashion hyperextending the lower thoracic, lumbar, and lumbosacral interlaminar joints (Fig 13) Next hyperextension being maintained first one and then the other thigh is dropped, so as to rotate the pelvis also (Fig 14) The legs are also carried from left to right so as to describe an arc in relation to the trunk This has a tendency to efface the list by mobilizing the lower thoracic and lum bar spine in the lateral directions

Discussion —Hyperextension of the lumbosacral joints is primarily intended although the maneuver rotates the ilium forward on the sacrum and tends to give clockwise rotation to the sacro-iliac joints Lumbosacral lesions which on roentgenologic analysis show a decrease in the intervertebral space with possibly marked angulation of sacrum on the lumbar spine and with constriction of the lumbosacral foramina are not submitted to this particular maneuver

Maneuver 9 —Passive straight leg raising according to the Baer technic of flexing the hip joint with the knee fully extended is car



spine at lumbosacral level, plus
and rotation of lumbosacral joint

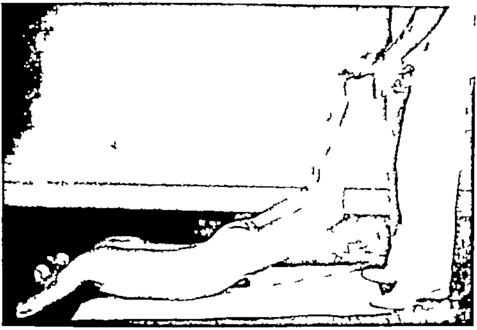


Fig. 13—Maneuver 8. Hyperextension of spine plus rotation of pelvis, first to left and then to right, with spine in hyperextension (Lumbosacral maneuver resulting in hyperextension plus rotation of joint.) The legs are likewise moved from left to right, so as to describe an arc in relation to the trunk. Has tendency to efface list by mobilizing lower thoracic and lumbar spine in lateral direction.

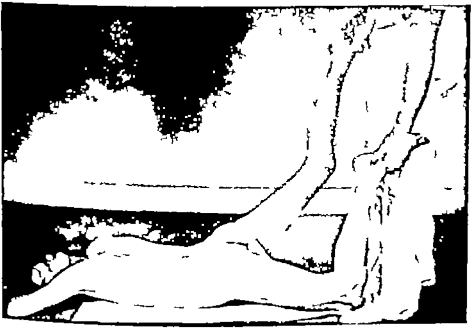
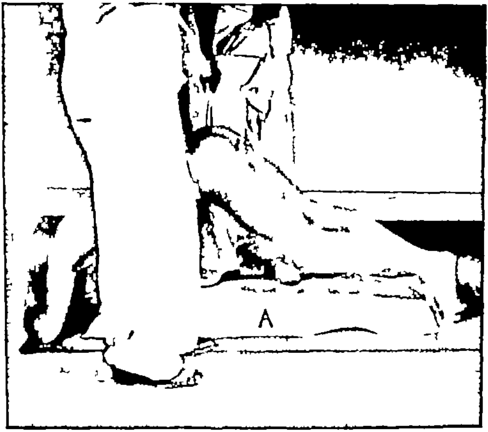
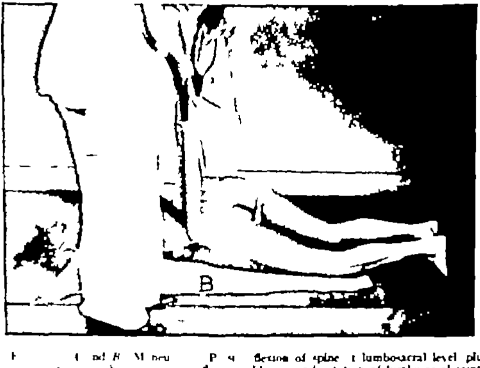


Fig. 14—Maneuver 8. Next, hyperextension being maintained, first one and then the other thigh is dropped, so as also to rotate the pelvis.





F ... A and B. M neu ... P ... flexion of spine at lumbosacral level plus ... Fle ... and ... tation of lumbosacral joint

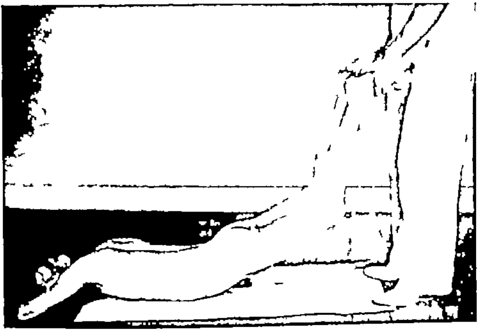


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Fig 14—Maneuver 8 vext hyperext ion bei g maint ined fi st one and then the ther thigh is dr pped, w ion to r tat the pel

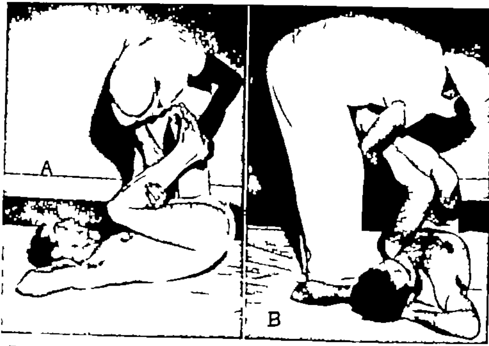

FIG. 15.—Maneuver 10. (*A*) Passive flexion of the lumbosacral joint. (*B*) Rotary flexion for mobilizing both the lumbosacral joint and lower lumbar and sacral interlaminar articulations.

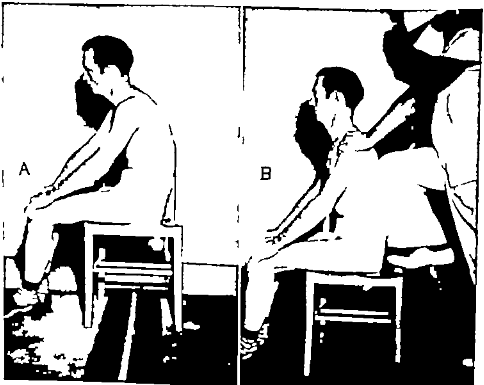

FIG. 16.—Maneuver 11. (*A*) Round back type of postural hump associated with mid-dorsal pain. (*B*) P[illegible] extension of the spine from abnormal flexion toward that [illegible] with mobilization of costovertebral articulations.

ried out on both sides The pumping movement is used to increase the range of flexion when pain is encountered and better relaxation is desired.

Discussion—It is noteworthy that, when this maneuver is carried out without anesthesia, and when passive straight leg raising is carried out on the affected side the pelvis on this side occasionally rises upward from the floor and rotates to the opposite side. This results from the patient s attempt to substitute abduction for forced flexion in order to escape further pain Hence the assistant operator holds down the iliac crest on the affected side

Résumé—This maneuver of course is primarily intended for sacroiliac mobilization

Maneuver 10—The manipulator places one hand and forearm about the legs of the patient steadying the patient s feet by means of his other hand. He then brings the patient s knees upward, flexing the hip joints so that the thighs approximate the abdominal wall (Fig 15 *A*) Then lifting upward so that the patient s pelvis is suspended clear of the floor he rotates the pelvis laterally on the trunk first in one and then in the opposite direction (Fig 15 *B*)

Résumé—This maneuver is intended primarily for mobilization of the lumbosacral joint and the lower lumbar and sacral interlaminar articulations

Maneuver 11—In low back conditions resulting from postural strain or otherwise associated with an abnormally rounded dorsal spine the patient very often complains of pain also in the mid-dorsal region between the scapulae With the patient in sitting position (Fig 16 *A*) the manipulator braces his knee against the patient s thoracic spine (Fig 16 *B*) and then grasping the shoulders draws them back ward, extending the spine against his knee in a movement tending to reverse the position from that of abnormal flexion toward that of hyperextension. The patient assists the maneuver by dropping his head and neck backward toward the manipulator

Résumé—This maneuver tends to relieve the dorsal kyphos by ex tending the thoracic vertebrae and it also mobilizes the costoverte bral joints It is employed only when indicated and is not routinely performed

Following Manipulation—The patient lies in the supine posi tion. He is now shown how to progress from the supine to prone position and from prone position to that of standing with the least effort and likelihood of further strain. It is definitely believed that many backaches are prolonged because of trauma produced by im properly executed movements Accordingly the patient is shown how to progress from the supine (Fig 17 *A*) to prone position—to roll over in other words without twisting his back. The manipulator

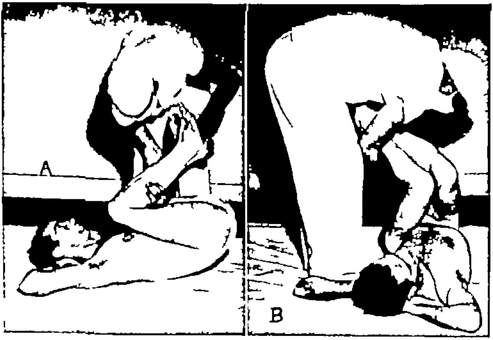

FIG. 15.—Maneuver 10. (*A*) Passive flexion of the lumbosacral joint. (*B*) Rotary flexion for mobilizing both the lumbosacral joint and lower lumbar and sacral interlaminar articulations.

FIG. 16.—Maneuver 11. (*A*) Round back type of postural slump associated with mild dorsal pain. (*B*) P[illegible] extension of the spine from abnormal flexion toward that of hyperextension with mobilization of costovertebral articulations.

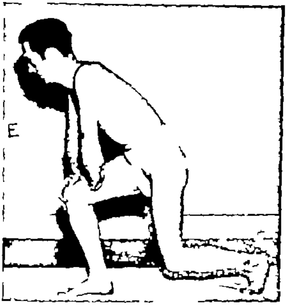

FIG. 17 (Cont.)—(E) When the hands approach the knees the patient puts the good foot forward placing it squarely on the floo lay both hands on the flexed knee and pushes downward, thus using the arms and the houlders to e tend the spine on itself and the hips instead of employing the back muscles normally coming into play in such a movement.

after having had the patient place his arms above his head rolls him over like a log shoulders and pelvis moving synchronously thus avoid ing any torsion or twist (Fig 17 B) The patient is asked now to change from the prone to the standing position by first coming to the knee-hand position (Fig. 17 D) keeping the spine arched in flexion as much as possible When the hands approach the knees the patient is asked to put the good foot forward (the foot opposite the site of pain) placing it squarely on the floor to lay both hands on the flexed knee and to push downward (Fig 17 E) thus using the arms and the shoulders to extend the spine on itself and on the hips instead of employing the back muscles normally coming into play in such a movement. Patients invariably welcome the relative ease with which they are now enabled to change position

POST MANIPULATIVE ROUTINE—Following manipulation the com parative ease with which the patient moves about attests the relief of muscle spasm and the acute radiating pain This outcome would prove quite short lived in many instances if the patient failed to observe more or less complete rest for a given interval Acute back cases must avoid activity and observe a period of rest For this reason when pa tients are manipulated in the hospital the bed is immediately made ready for them There are boards under the mattress. The mattress is never an innerspring type but one made of felt The authors feel that the innerspring mattress is the most debilitating of modern con

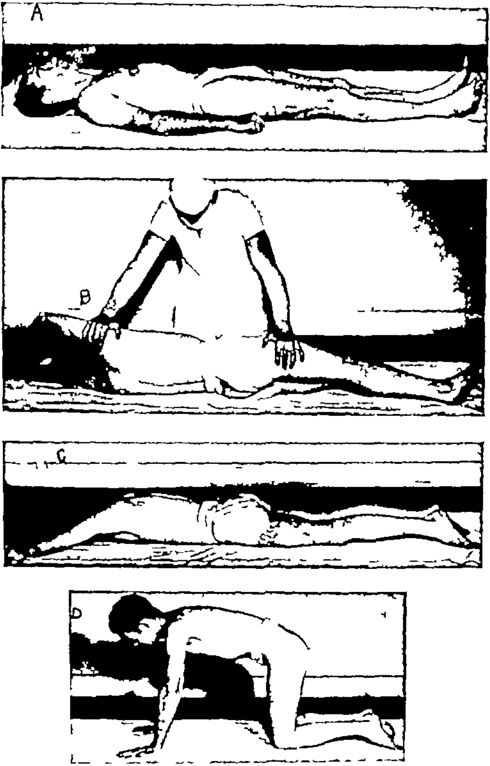

FIG 17.—Proper method for patient with acute low back pain to rise from floor
(A) Supine position
(B) Rolling over like a log to avoid any twisting of the back and resulting pain.
(C) Prone position
(D) Patient changes from prone to knee hand position, keeping the spine arched in flexion as much as possible

FIG. 7 (*Cont*).—(*E*) When the hands approach the knees th pati t puts tl good foot forward placing it squarely on the floo lay both h l the flexe l knee and pushes dow ward, thus using the arms and the sh kl rs t t nd the pine n itself and on the hips instead of employing the back muscles all ming int play in such a movement

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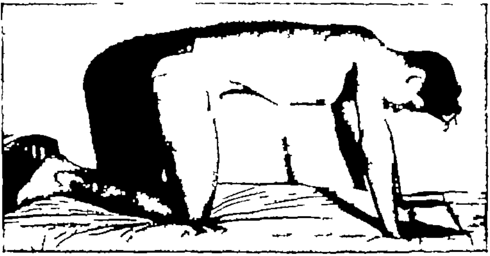


FIG. 18.—The knee hand position used in the correct method of getting up from the floor or getting in and out of bed.

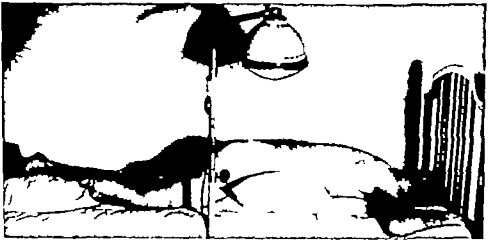


FIG. 19.—The ideal type of heat is the infra-red lamp. With the standard type it is applied at a distance of 30 inches from the patient's back for the duration of 30 minutes every 4 hours throughout the day. Three pillows are placed in crisscross fashion and over these the patient places the upper part of his pelvis and lower abdomen. In such position, the patient's lumbosacral region should be well arched, stretching and relaxing his sacrospinalis muscles. The hot water bottle or electric heat pad is utilized in this same manner if no infra red lamp is available. In warm weather when radiant heat may prove objectionable, diathermy may be applied routinely with the patient in this prone position.

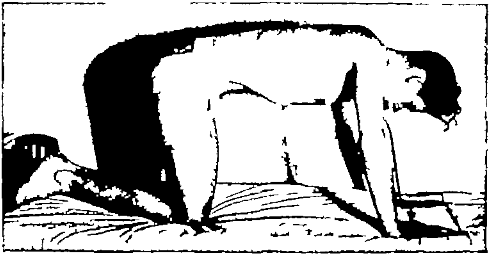
trivances and constitutes a curse of the present era. Pillows are assembled in the middle of the bed and the patient is shown how to get into the bed properly.

He steps up on the stool with the right foot (given an involvement of the left side) followed by the left foot. Both hands and the right knee are placed on the bed. Bearing all weight on the right knee he then brings up the left knee and assumes the knee-hand position on

the bed (Fig 18) Moving over to the middle of the bed he lies prone over the pillows thus flexing the low back. A pillow is placed beneath his feet so that the resultant mild knee flexion relaxes the hamstring muscles Infra red heat at a distance of 30 inches is applied for 30 minutes (Fig 19) This latter routine is repeated every four hours. Twice a day the patient practices alternate straight leg raising, and he is manipulated as often as the condition warrants Special attention is paid to nursing details and no type of bed pan other than the special orthopedic bed pan is ever allowed The ordinary type of bed pan very often aggravates or precipitates an acute attack as quickly as would any other awkward movement and should be avoided. In getting out of bed the patient assumes first the prone position, then the knee hand position he then moves the knees over to the edge of the bed and bearing weight on the left knee lets himself down on the right foot followed by the left

The usual duration of hospitalization for the chronic case is ten to fourteen days that for the acute case from two to three days On discharge the patient is generally equipped with some type of support such as a canvas belt or a high-back corset. He continues the routine of heat and exercises at home as he did in the hospital A rather important phase of post manipulative treatment is the education of the patient to the business of saving himself from further trauma and sprain in performing his daily activities Besides the proper methods of getting in and out of bed he is taught how to arise properly from a sitting position and vice versa (most important in lumbosacral involvements) how to lean over properly and to arise from a stooping position and how to drive his car with the least fatigue Patients seen in the office and the home are made to follow the same routine of complete rest heat and exercises that is prescribed in the hospital With the satisfactory alleviation of pain relaxation of muscle spasm and correction of the list the patient is again allowed to introduce himself into his usual normal employment.

Discussion —This manipulative technic is not offered as a cure for all cases of low back pain. Rather it is presented as another adjunct to the physician s armamentarium in the treatment of one group of low back conditions It is not always sufficient in itself but must be followed up by other orthopedic measures Postural defects not the immediate result of acute muscle spasm—such as pronated feet internally rotated femora relaxation of the lower abdominal wall lordosis with an anteriorly tilted pelvis contracted sacrospinalis muscles flat chest and round back etc.—are noted and corrected By the systematic strengthening of the abdominal muscles and the stretching of the shortened sacrospinalis muscles the pelvic tilt is corrected and the abnormal lordosis is obliterated An occasional patient presents a marked anterior tilt of the pelvis and as demonstrated by the Ober abduction and Ely tests a definitely contracted fascia lata. Routine corrective exercises are definitely impeded by the shortened fascia and in these



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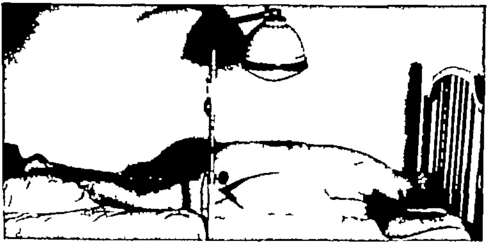

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(a) The patient rolls his pelvis over a pillow by pulling up in front with his abdominal muscles and down in back with the buttocks This also flattens the low back.

(b) Lying upon his face he lifts upward first one lower extremity and then the other keeping the knees extended Both exercises are done either on a hard bed or on the floor They are done five to ten times twice a day

Posture Correction and Exercises —In order to learn how to eliminate the fatigue posture of flat chest round back relaxed lower abdominal wall and sway back the patient stands with his back to the wall his feet being some three inches from the baseboard With toes straight ahead and knees slightly bent he rolls his weight to the outer borders of the feet by pulling up under the arches and rolling the legs outward by pinching the buttocks together Then he rolls his pelvis to flatten the low back against the wall by pulling up and in with his abdominal muscles and down with the buttocks Holding this position he then steps away from the wall.

(a) *Shoulders and Breathing* Arms extended backward the hands are grasped behind the back. The shoulders are thrown back as far as possible and a deep breath is taken Then the patient bends forward carrying the stretched arms high over the head meanwhile looking upward This exercise is repeated ten times

(b) *Round Shoulders* For fifteen minutes twice each day the patient may lie on a hard flat surface (table or floor) with a narrow sandbag just between the scapulae and extending halfway down the spine The feet should rest flat on the floor or table in their normal position with knee bent.

(c) *Abdomen* The patient may lie flat on back on a hard surface preferably a table or the floor The legs are spread as far apart as possible shoulders well back. Then the legs are raised from the floor keeping the body flat on the floor This hould be repeated ten times

(d) *Lordosis Hip Extension and Flexion* Stand erect, arms folded on chest Take deep breath and raise right leg with knee bent until thigh rests on abdomen Hold for a few seconds and then repeat with left leg Repeat ten times each.

(e) *Scoliosis* Place hand of same side high up under arm where ribs are most prominent. Place other hand flat on side of head and then push with both hands thus attempting to overcorrect abnormal curve of spine.

(f) *Normal Sitting Position* Sit well back in chair so that buttocks touch the back of the chair then the entire back should fit snugly against the back of the chair Throw the shoulders back and keep the head high and not tilted forward so that the chin rests on the chest.

Foot Exercises —The deformity of pronated ankles (sagging inward of both ankles) results from an imbalance of the peroneal and

instances section of the fascia according to the Ober technic hastens the correction of the abnormal pelvic tilt, allowing for more effective shortening and strengthening of the abdominal muscles Following failure of the conservative regimen, the various operations for the correction of known anatomic defects must be considered This alternative fortunately has not been a frequent one in our experience The likelihood of a favorable prognosis in the conservative treatment is much enhanced, of course the earlier the condition is seen and treated. As a rule it is much easier to correct the condition completely by treating the initial attack than by treating the latest of a series of attacks over a period of years

Exercises.—Exercises play an important role in the treatment of backache. In the earlier part of this discussion we noted that many painful backs result from postural imbalance The need for strengthening the weakened muscles and re-establishing muscle balance should be obvious Corrective apparatus that may be prescribed is also intended to serve as a constant reminder for the patient to observe normal posture as well as to act as a support during periods of fatigue. The patient that understands why he is to take these routine exercises and the manner in which muscular tone is gradually increased will better appreciate their importance and become more faithful in their daily performance. Time should be taken to explain these things to him.

Straight Leg Raising —The exercise is included as part of the post manipulative routine outlined previously Usually these low back conditions have an associated shortening of the hamstring muscles which in their tension transmit strain to the sacro-iliac joint. These exercises are intended to stretch regularly and frequently the hamstrings in order to overcome any contracture or muscle spasm. Secondarily they serve as a measure of progress for when the patient can do straight leg raising to a full 90 degrees again without discomfort his back condition is usually completely relieved The exercises are done twice daily ten times with each lower extremity and performed alternately They are usually done after the infra red therapy has been given to the lumbar and sacro-iliac regions.

Gluteal Exercises.—These exercises are prescribed not only for cases of low back pain but for coccygodynia as well In the former there is a unilateral relaxation and atrophy of the gluteal muscles secondary to the painful focus in the latter it is possible that atrophy of the gluteals renders the tip of the coccyx exposed to further trauma every time the person assumes the sitting position The gluteal muscles are exercised and their tone brought back to normal by the following exercises

(a) The patient rolls his pelvis over a pillow by pulling up in front with his abdominal muscles and down in back with the buttocks This also *flattens the low back.*

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(a) The patient rolls his pelvis over a pillow by pulling up in front with his abdominal muscles and down in back with the buttocks This also flattens the low back.

(b) Lying upon his face he lifts upward first one lower extremity and then the other, keeping the knees extended. Both exercises are done either on a hard bed or on the floor They are done five to ten times twice a day

Posture Correction and Exercises.—In order to learn how to eliminate the fatigue posture of flat chest round back relaxed lower abdominal wall and sway back, the patient stands with his back to the wall his feet being some three inches from the baseboard With toes straight ahead and knees slightly bent he rolls his weight to the outer borders of the feet by pulling up under the arches and rolling the legs outward by pinching the buttocks together Then he rolls his pelvis to flatten the low back against the wall by pulling up and in with his abdominal muscles and down with the buttocks Holding this position he then steps away from the wall

(a) *Shoulders and Breathing* Arms extended backward the hands are grasped behind the back. The shoulders are thrown back as far as possible and a deep breath is taken Then the patient bends forward carrying the stretched arms high over the head meanwhile looking upward This exercise is repeated ten times

(b) *Round Shoulders* For fifteen minutes twice each day the patient may lie on a hard flat surface (table or floor) with a narrow sandbag just between the scapulae and extending halfway down the spine The feet should rest flat on the floor or table in their normal position with knee bent.

(c) *Abdomen* The patient may lie flat on back on a hard surface preferably a table or the floor The legs are spread as far apart as possible shoulders well back Then the legs are raised from the floor keeping the body flat on the floor This should be repeated ten times

(d) *Lordosis Hip Extension and Flexion* Stand erect arms folded on chest Take deep breath and raise right leg with knee bent until thigh rests on abdomen Hold for a few seconds and then repeat with left leg Repeat ten times each

(e) *Scoliosis* Place hand of same side high up under arm where ribs are most prominent. Place other hand flat on side of head and then push with both hands thus attempting to overcorrect abnormal curve of spine

(f) *Normal Sitting Position* Sit well back in chair so that buttocks touch the back of the chair then the entire back should fit snugly against the back of the chair Throw the shoulders back and keep the head high and not tilted forward so that the chin rests on the chest.

Foot Exercises.—The deformity of pronated ankles (sagging in walk of both ankles) results from an imbalance of the peroneal and

tibial muscles Because the peroneals are much stronger the ankles become quite pronated, thus stretching and further weakening the tibial groups. Foot exercises are therefore directed toward the strengthening of the tibials by eliminating the peroneals from the exercise.

(a) 1 In sitting position, cross legs Start with the foot relaxed.
2 Bend toes downward as if to grasp something
3 Turn foot inward.
4 Bring foot upward, keeping the toes bent downward and hold for three seconds
5 Relax foot. Repeat six times to the minute for three minutes

In the above, 'keeping the toes bent downward" is emphasized in order to prevent substitution of the extensor of the great toe for the anterior tibial muscle. For stretching a shortened tendo achillis,

(b) Face the wall, standing about three feet away The feet are turned in as if pigeon-toed. Then lean forward placing the palms of the hands on the wall. By next bending the elbows the head and chest approximate the wall while the heels are held to the floor as much as possible A strong tension will be felt in the calves of the legs. As one becomes accustomed to the exercise stand farther away from the wall, thus producing more tension.

Protective Treatment.—The patient who complains of an acutely painful back should be made to cease all activity and to assume a period of bed rest. Continued physical activity and weight bearing at this time will not 'wear off the pain' but will aggravate the lesion and the muscle spasm There are many instances in which the consignment of the patient to bed does not bring about the complete rest and relaxation desired. The patient might even experience an aggravation of the pain In these instances the fault lies not with the mode of treatment but with the imperfections of the bed.

The bed A patient is consigned to bed in order to cease all activity and weight bearing, thereby affording rest to his back. However, if the particular bed sags down under the weight of the patient gravitational stress causes as much pain as if the patient were standing or moving about. The bed must be a hard one. This need not deny comfort to the patient. Every such bed in the hospital is equipped with fracture boards. For a patient in the home, boards of 12 by 1 dimensions may be ordered or better yet the lumber company can also supply pieces of ¾ inch 5 ply of 6 by 3 ft. dimensions. If such is needed for a double bed two such pieces of 5-ply are ordered. If the bed is not of standard size it should be measured first so that the lumber company can cut the 5-ply to the desired proportions.

The mattress must be of the solid type, not innerspring It should be made of tightly compressed felt. The mistake should not be made of getting such a mattress too thin. A thin solid mattress over boards will yield as little comfort as sleeping on the floor This solid type of mat

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The principle of protection is not forgotten because the patient has recovered from his attack of back pain or because he is entirely free from symptoms Many recurrences of back pain are produced because the patient performs carelessly any one of many routine activities. Under the heading "Manipulation and in the sections on Preparation of the Patient, Following Manipulation and "Post manipulative Routine the proper manner in which the patient gets down to the pad gets up again gets in and out of bed is explained in some detail He is further advised to avoid using overstuffed upholstered furniture but to use instead solid hard chairs In sitting down he is taught to place both hands on his knees thereby throwing his weight and effort onto the musculature of his arms and legs rather than on the back muscles which normally come into play in the execution of such a movement He arises from the chair in the same manner (Fig 20 *A* and *B*)

If the upholstery of the car which he drives is replete with springs so that his hips and pelvis jackknife and his back leans posteriorly 45 degrees or more the inefficiency of this position for alert driving and the fatigue resulting from strain on his neck back and buttocks are made known to him (Fig 21 *A* and *B*) Hard folding seats to support the low back and buttocks are available in most auto accessory stores Lifting heavy objects such as luggage etc. should not be executed with a rotary or torsion movement of the spine The object to be lifted should be directly in front of him rather than to one side or the other Laborers are taught to lift heavy objects by substituting their leg and thigh muscles for the low back muscles in the process of raising the objects (Fig 22 *A* and *B*) In the case of a patient who does housework such items as the length of the handles of brooms and mops of the height of the table at which she habitually works of her custom of standing for performing certain duties when sitting would be more advantageous etc., are all checked in order to avoid unnecessary back strain. This is rather important to those people who must carry on their chosen work in spite of inherent back pathology Raising a window in an awkward manner has precipitated many attacks of low back pain (Fig. 23 *A* and *B*)

Protection is further obtained over more or less prolonged periods of time by means of strapping stockinette swathe or the various types of support about to be described. The authors prefer not to strap a back with adhesive tape The adhesive slides over the skin and soon loses its purchase the skin is traumatized adding to the discomfort of an already distraught patient. A far more efficient and comfortable mode of splinting is obtained by using a circular bandage of stockinette material held in place by safety pins and if necessary by thinner perineal straps

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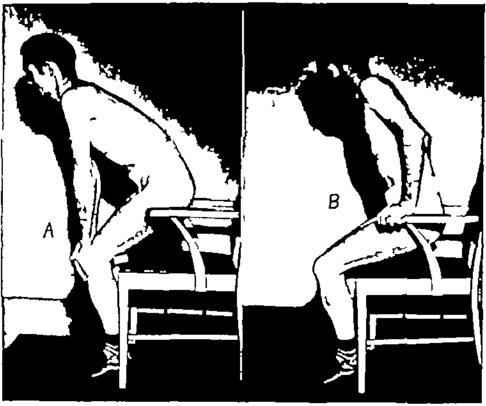

FIG. 10.—(*A*) Proper method of arising from sitting position. Hands are placed on the knees and most of ffort is borne by arms and legs. (*B*) Improper method.

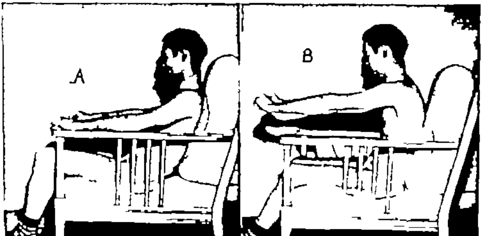

FIG. 11.—(*A*) Position assumed in overstuffed furniture or "springy" automobile seat. (*B*) Position necessary if driver is to be alert in traffic—the sagging buttocks and flexed low back are subject to considerable strain.

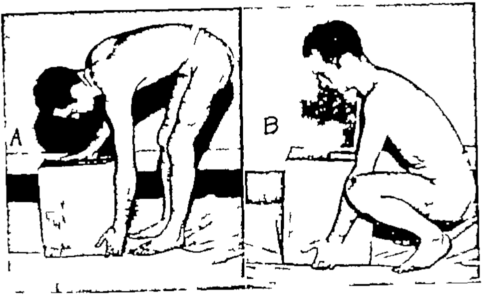

FIG. 22.—(A) Improper method f lifting heavy object. (B) Proper method.

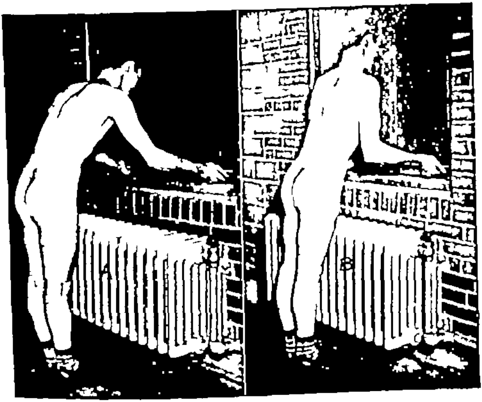

FIG. 23.—(A) Awkward manner f raising window. The low back is flexed so that most strain will be concentrated in this area. (B) Proper method. Thighs are as close to window as possible. Low back is held straight rather than leaning forward in flexed position. Both hands should exert equal force.

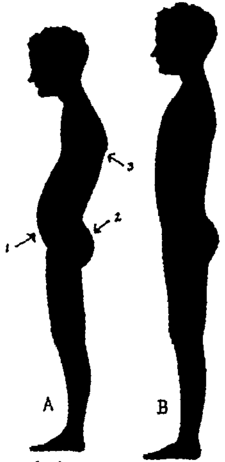

FIG. 24.—(*A*) The abnormal spine curves seen in fatigue posture. The directions of corrective force (1) upward pressure upon the lower abdominal wall (2) downward and forward pressure on the buttocks and (3) upward and forward pressure at the mid-thoracic region. (*B*) The normal upright position.

More rigid supports comprise the following

(a) The Osgood belt This is rather simply composed of a sacro-iliac pad in back and a lower abdominal lifting pad in front, joined on the sides by several leather straps While this means of support is quite effective in the treatment of sacro-iliac lesions a frank lumbosacral may continue to be painful because such a support does not adequately immobilize the upper part of the lumbar spine.

(b) The canvas belt is another means of support for sacro-iliac conditions and it likewise may fail to relieve a lumbosacral condition.

(c) In the instance of severe and frank lumbosacrals a Goldthwait brace which incorporates the principles of the preceding two but is more rigid and includes the whole lumbar spine, is most satisfactory

(d) A Thomas back brace lends itself successfully to the support of the spine whose affections are in the upper lumbar and mid thoracic regions especially tuberculous spines.

(e) The Hoke jacket is an excellent means of holding mild and moderate scoliosis deformities.

We have seen that lesions involving the greater part of the spine whether postural inflammatory etc. lead to an accentuation of the normal curves The curves seen in fatigue posture are an illustration (Fig 24 *A*) In order to return the spine to its normal upright position (Fig 24 *B*) and so correct faulty weight bearing it is necessary for the support to exert upward pressure upon the lower abdominal wall downward and forward pressure on the buttocks and upward and forward pressure at the mid thoracic region. These directions of corrective force are indicated in Figure 24 *A* by the arrows 1, 2 and 3 The following supports serve such purpose

(f) The Taylor spine brace This type of support may be used in the correction of adolescent round back whether postural or resulting from vertebral osteochondritis Kummell s disease of the spine following reduction of compression fracture of the spine extreme fatigue posture in adults in conditions of muscular dystrophies tuberculosis and syphilis of the spine malignancy and arthritis

(g) A well-stayed high back corset either with or without the addition of a Taylor spinal brace serves the same purposes for female patients as those outlined immediately above It might be well to add that a large number of female patients suffering from fatigue posture and its attendant low back pain secure ready relief from such upon wearing this type of well-stayed high back corset to which may be added at the discretion of the physician an abdominal lift or sacroiliac pad.

In conclusion a plea is made for occupational therapy If during the course of the treatment of backache an energetic patient is forced to discontinue a busy routine for a time other tasks should be introduced to pass his time and occupy his mind

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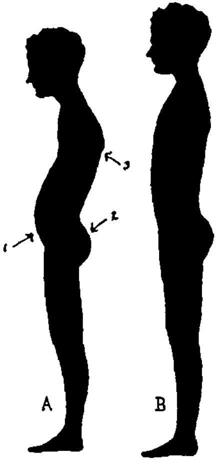

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CHAPTER TWENTY FOUR

PHYSICAL THERAPY IN THE TREATMENT OF PERIPHERAL VASCULAR DISEASE

GEZA DE TAKATS M D M.S F.A.C S

The object of physical therapy in the treatment of peripheral vascular disease is to improve circulation in the affected extremity This improvement may be brought about by *enlargement of the vascular tree by actual increase in the volume of blood flowing through the part in a unit of time* or by *hastening the absorption of exudates and indurations* which in turn favors better nutrition and increases lymphatic or venous drainage. The various procedures found useful in circulatory disturbances will be described under the headings of *heat and cold massage postural exercises roentgen therapy radium therapy suction and pressure therapy intermittent venous hyperemia* and *iontophoresis* Only measures with which our group has had personal experience will be discussed No attempt will be made to describe the technic of administration as this has been done in other chapters. Nor is it my purpose to describe the physiologic effects of these therapeutic measures as they have been dealt with elsewhere (Vol I Chap 4 Vol. III Chap 2)

HEAT AND COLD

The typical response of the vascular tree to changes in temperature is vasodilatation to warmth and vasoconstriction to cold This reaction may be elicited in areas devoid of all nerve supply It must be remembered however that excessive cold may produce flushing of the skin and vasodilatation whereas excessive heat results in pallor of the skin and vasoconstriction These paradox reactions are produced roughly below 15 C (59 F) and above 45 C. (113 F) and may be simply referred to as overcooling or overheating Packing an ischemic extremity in ice has recently been advocated by Frederick Allen [1] in order to eliminate toxic absorption from the necrotizing or necrotic tissue and to eliminate pain as such an extremity becomes so numb that it can be amputated without any further anesthesia. It should be made clear that this freezing is never to be employed if there is any chance or hope to save the limb If the extremity is hopelessly lost the placing of four to six icebags around and above the gangrenous part definitely decreases the rapidity of absorption. Whether it should

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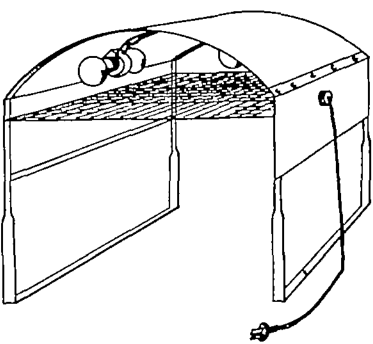

Fig. 1.—Electric lamp baker

Specifications	Large Size
Length	20 inches
Width	20 inches
Height	20 inches
Size of tin	20 by 18 inches
Size of screen	16 by 20 inches

Screen made of 4 mesh galvanized hardware cloth attached to frame 5 inches from top t center
Frame ¼ by ½ inch gal anized bar iron.
Reflecto highly polished tin sheeting.
Altitude of arc of reflector 5 inches.
Two double receptacles, General Electric Company catalogue 66722 250 volts, 650 watts
Four 60-watt Mazda lamps.
The tin is riveted to the ir n. Receptacles are connected in multiple with heavy lamp cord 6 feet long. Hubble plug at end of cord.
The baker is designed f r applying heat to the legs r arms. If th baker is to be used for the body supports should be 2 or 3 inches longer

(Courtesy of J.A.M.A., April 5 941.)

be used as an anesthetic for amputation is still not clear as objections may be raised as to the viability of the overcooled segment at the level of amputation This is especially true of limbs with vascular *impairment whereas in amputations for trauma, where circulation is* intact and abundant proximal to the injury, the effect of low temperatures on blood supply is probably less harmful. Both clinical and animal experiments show that an extremity with normal circulation can remain vitalized for a day or two after a tourniquet is applied provided the environmental temperature is near freezing

The effect of too much *heat* in an ischemic limb is deleterious. An ischemic limb tolerates heat poorly as it is unable to respond with

sufficient vasodilatation Besides the increase in cellular metabolism brought about by higher temperatures demands more blood than the narrowed or plugged arterial channels can supply For this reason an extremity which is painless at room temperature may become very painful if placed in a heat cradle even if this is thermostatically controlled between 85 and 95 F (29.4 and 35 C) Each ischemic limb has a critical temperature above which it becomes painful. The complaints of patients under heat cradles have been ignored too often Not only is the extremity painful under moderate heat but gangrene may be accelerated following an acute arterial occlusion when the cooling system of a normal vascular bed is out of order and the accumulated heat hastens tissue destruction

An ischemic extremity therefore should not be placed in a heat cradle but simply wrapped up in cotton or covered with a flannel boot. Heat should be applied to the root of the limb centrally to the obstruction of the vascular bed The increase in blood flow which occurs from applying indirect heat, is not any less than if heat were applied directly to the extremity [2] Vasodilatation is still produced both by heating of the blood at the root of the limb and by producing reflex vasodilatation which is mediated by the sympathetic nervous system. Thus in a sympathectomized limb one cannot obtain reflex vasodilatation.[3]

For practical purposes a large heat cradle covering the abdomen and the upper third of the thigh is the best and cheapest way to treat a limb with impoverished blood supply One or two 40-watt bulbs may be sufficient. The object of such a cradle is to heat the vascular tree where it is intact and not where it is deficient. While short wave diathermy [4] or heating sleeves [5] are useful in producing reflex vasodilatation they are not any more efficient than a large cradle which can be readily constructed in any hospital The measurements of such a cradle are given in Figure 1

Unless such cradles are used continuously in the bedridden and overnight in the ambulatory patient their employment for short periods of time such as half an hour three times a day is of doubtful value.

Warm soaks or warm sitz baths the temperature not exceeding 95 F (35 C) are useful before going to bed to warm up the limb for the night, followed by a gentle rub with lanolin and a seamless wool sock Also in some forms of machine therapy such as in intermittent venous hyperemia or suction and pressure treatment, a warm soak or a heat cradle is a useful adjuvant measure

Alternate hot and cold baths used to stimulate circulation have and are being used extensively It is difficult to see the benefit to be derived from their use. Cold contracts heat dilates the peripheral vessels. If they are *rigid as in arteriosclerosis the method cannot do much good* If the small arteriovenous shunts are involved in the vascular disease and are not reacting normally as heat regulators the terminal vas-

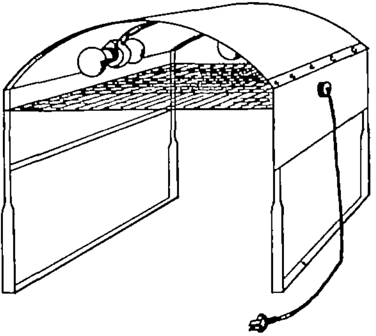

Fig. 1.—Electric lamp baker

Specifications	Large Size
Length	20 inches
Width	20 inches
Height	10 inches
Size of tin	20 by 8 inches
Size of screen	16 by 10 inches

Screen made of 4 mesh galvanized hardware cloth attached to frame 5 inches from top t center
Frame 1/8 by 1/2 inch galvanized bar iron.
Reflector highly polished tin sheeting.
Altitude of arc of reflector 5 inches.
Two double receptacles, General Electric Company catalogu 667 2 50 volts, 650 watts.
Four 60-watt Mazda lamps.
The tin is riveted to the iron Receptacles are connected in multiple with heavy lamp cord 6 feet long. Hubble plug at end of cord.
The baker is designed f r applying heat to the legs o arms. If the baker is to be used for the body supports should be 2 or 3 inches lo ger

(Courtesy of J.A.M.A., April 5 1941)

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The effect of too much *heat* in an ischemic limb is deleterious. An ischemic limb tolerates heat poorly as it is unable to respond with

other hand arterial inflow is increased by gravity venous outflow is lessened, and there develops a dependent cyanotic edema, if patients are allowed to sit up all night and hang their feet over the side of the bed The *Buerger Allen exercises*[6] carried out as a ritual day after day, have the advantage in that they do not require any apparatus

The legs are placed in three positions In position 1 the patient elevates his legs to an angle of 30 to 45 degrees He keeps them there until the feet are completly blanched which takes about two minutes. In position 2 the legs hang over the side of the bed until they turn a deep pink. This may take from one to three minutes While the feet are dependent, the feet and toes are exercised. The ankle is flexed down and up the foot is rolled inward and outward and the toes are spread apart and closed When the dependent rubor is satisfactory the third position is assumed in which the patient lies supine the legs horizontal in bed and wrapped up in a woolen blanket. This position is maintained for five minutes

The entire cycle then takes about ten minutes and is repeated three times. Four such half hour sessions are recommended daily

The exercises are valuable but have definite disadvantages They are strenuous for many of the feeble and cardiac patients and are impossible for the patient who has just suffered an acute arterial occlusion. They use up considerable blood supplying the contracting muscles and thus divert blood from the ischemic tissues They are frequently prescribed but the patient will not do them long enough to obtain sufficient benefit.

The *oscillating bed* is nothing else but a mechanical means to obtain alternate elevation and dependency The patient lies quietly without exertion in bed and the exercise can continue day and night. Barker[7] feels that the oscillating bed is a valuable addition to the armamentarium in the treatment of peripheral vascular disease A short study of the apparatus in our clinic made it clear that (1) the apparatus can only be used in large hospitals and its cost to the patient is high (2) Alternate filling and emptying of the vascular bed occurs not only in the affected limbs but in the splanchnic pulmonary and cerebral vascular bed. (3) The effect on these areas is usually not harmful but may become so unless the treatment is followed very closely by the physician. Cerebral thrombosis and pulmonary edema may develop (4) Outside of attracting patients to the hospital the apparatus has no advantage over other mechanical means which alternately fill and empty the minute vessels

Roentgen Therapy

Radiation of patients suffering from peripheral circulatory disturbances has several objectives It may be used to produce reactive hyperemia in poorly vascularized tissues and one can immediately state

cular bed may receive less blood by diversion of the blood stream through the shunts If the disease is wholly or partially vasospastic, the alternate hot and cold baths exaggerate vascular spasm. Broadly speaking, the diseased vascular tree does not need exercise it needs rest. Its function and capacity are delicately regulated by metabolic needs and by the heat regulating mechanism through the vasomotor nerves This must be emphasized, as the most frequent advice to patients suffering from peripheral circulatory disease is to use alternate hot and cold baths. The benefit derived from their use can be more simply obtained either by warm soaks or from the production of reactive hyperemia.

Cold baths especially cold foot baths, are empirically used by patients suffering from erythromelalgia to relieve intractable burning pain. While a temperature of 40 C (104 F) gives a pleasant sensation of warmth to the normal foot or hand such patients mostly suffering from polyneuritis or from a hyperalgesic state following freezing or burns find relief in a bath of 20 to 30 C (68 to 86 F) Severe cooling however is again painful and patients have shown remarkable ability to discover and maintain a critical temperature above or below which pain develops Such cool baths are, of course, of no curative value as the underlying cause of erythralgia has to be treated but they are very useful in alleviating pain.

Massage

The physiologic effects of massage have been discussed in Volume I, Chapter 6 In circulatory disturbances affecting the arterial or lymphatic channels a gentle massage starting from the periphery toward the root of the limb often relieves pain, reduces swelling and produces a mild reactive hyperemia. Lanolin is useful as a lubricant as it softens the dry cracked skin of ischemic limbs prevents fissures and heals small cutaneous defects. Patients frequently get relief from rubbing their cold numb extremities and physicians should never ignore such simple empiric measures which have proved their worth for centuries As arterial obstruction may be associated with venous thromboses one should be certain that no such complication exists Venous thrombosis phlebitis or lymphangitis is an absolute contraindication of any kind of massage but a chronic lymphedema may soften and decrease in size by vigorous kneading

Postural Exercises

Lowering and raising an extremity or some other part of the body alternately empties and fills the peripheral vascular tree. During elevation an ischemia develops and it is well known how severely patients suffer when their extremity, already handicapped by impaired arterial inflow is kept constantly elevated. In a dependent position on the

FIG. 2—Case of E C., 10-year-old girl with a large, cavernous hemangioma over the left scapula. This vascular mass had been treated previously with radium and ray but unsuccessfully A number f sclerosing injections were made into this mass with 5 and per cent potassium oleate, following which the entire mass was excised. Dr Paul W Greeley placed a split thickness skin graft on the remaining defect. Such ascular masses are far better treated with a combination of sclerosing injections and excision than by radium and x ray

angioma invades deeper structures such as subcutaneous tissue muscle or even bone a combination of sclerosing injections arterial ligations and surgical excision and skin graft may become necessary Such a case which had been treated by roentgen ray and radium for a long time without success is shown in Figure 2

One other condition which often defies relief by any other measure namely erythralgia, can be treated by radium packs The continuous burning pain which is aggravated by friction and heat is relieved temporarily by moist cold packs or cold baths as mentioned above. It is not a disease but a state of cutaneous hyperalgesia which accompanies many widely different diseases such as polyneuritis arteriolar sclerosis polycythemia or may follow frostbites or burns It is probably due to the release of vasodilator substances in the skin. Of all the palliative measures radium seems to afford the best relief George Brown [13] was impressed with the help radium offers in this condition It may be the only method of obtaining relief if no etiologic factor can be discovered.

that this is an objectionable and dangerous procedure. Reactive hyperemia is the result of tissue damage and that should be avoided at all costs in ischemic areas A small dose of roentgen ray may produce deep necrosis in avascular areas.

A second line of approach is the attempt to radiate the sympathetic trunk or ganglia in patients suffering from vascular disease with the idea of blocking the sympathetic nervous system by roentgen therapy Thus favorable reports of treating Buerger's disease and Raynaud's disease by radiation of the sympathetic chain have come from Rothberg [8] and others There is no evidence that heavy radiation of this area ever results in sympathetic denervation as manifested by vasodilatation rise in skin temperature or cessation of sweating. Attempts to treat vasospastic disorders or cases of hyperhidrosis with this method completely failed in our hands It is likely, however that the retroperitoneal lymphangitis and lymphadenitis which are often present in Buerger's disease, are favorably influenced by roentgen therapy

The real field of roentgen therapy in circulatory disorders is that of phlebitis periphlebitis and lymphangitis At St. Luke's Hospital Chicago over 100 cases of acute and subacute phlebitides have been treated by x ray [9] When the phlebitis is superficial one can follow the result with the naked eye and the palpating finger As customary in inflammatory lesions the more acute the lesion the smaller the dosage must be In fact roentgen ray may activate a latent phlebitis [10] In acute cases of red swollen cords not more than 50 to 80 r units are given with heavy filter, in the subacute cases 100 to 125 r have proved optimal. From four to ten treatments are given every third day Larger doses or doses given too close, may activate the process and even produce septic temperatures When the phlebitis is deep located in the iliofemoral segment, the effect on pain and edema is soon noticeable The effect of the treatment is obviously on the periphlebitic exudate on the lymphocytes and leukocytes which are notoriously radiosensitive. The treatment will not affect the thrombus but hastens the cooling of the active process and treats the accompanying lymphangitis. In chronic thrombophlebitic edema or in lymphedema, roentgen therapy is useless or may even increase the edema if the dose is too heavy and destroys some of the lymph glands

An equally excellent response is obtained in cases of acute reticular or tubular lymphangitis. We have had no experience with radiating the spleen in cases of migrating phlebitis [11]

The treatment of nevi and cutaneous angiomas has been discussed in Volume I Chapter 18 and Volume III Chapter 4.

Radium Therapy

Radium in vascular disease is commonly used in the vascular birthmarks of young children When such birthmarks are limited to the skin radium therapy is effective If the cavernous angioma or racemose

patients seek medical advice at this stage only 4 out of 100 patients belonged to this group in our original series[14] However in examining patients at more advanced stages of peripheral vascular diseases often the other so-called good leg' is in this stage it should be intensively treated. In the second group 42 out of 100 were patients in whom claudication developed after two blocks and whose oscillometric index was one half or less at the ankle. In this group the response after ten treatments is definite only 5 per cent showed no improvement after ten treatments but 15 per cent showed no result after fifty treatments In the later stages larger and larger percentages of failure were encountered In the third group we classified patients who had pain at rest and whose oscillometric index was zero at the ankle The fourth group had frank gangrene in addition.

In a large dispensary clinic such as at the University of Illinois the results can often be sized up by the percentage of patients who fail to return after ten treatments Exactly one half of the patients continued with their treatments after the first ten. Whereas in the first group none stayed away 38 per cent discontinued their treatment in the second group and 50 per cent stayed away from the third group The fourth group could not be followed at all after ten treatments they either died or amputation was performed.

In order to find simple objective measures for improvement one may rely on (1) return of pulsations (2) improvement of oscillometric curves (3) increase in claudication time and (4) the healing of ulcers or small patches of gangrene Patches of gangrene may readily separate and heal if the foot is warm and either the main arteries or their collaterals are patent.

The most sensitive measure of improving circulation is the venous filling time of Collens and Wilensky[16] This test done before and during the course of treatment may give information regarding improvement in the circulation time of the affected limb The extremity is elevated as in the Buerger Allen exercise and thus the dorsal veins of the foot are emptied. Next, the patient is asked to sit up and hang his feet down The dorsal veins of the foot will fill with blood normally in less than ten seconds in case of arterial obstruction it may take one to two minutes for the veins to fill through the capillaries

I have modified this test by keeping the patient horizontal after the initial elevation. The thigh is now constricted with a pressure of 60 mm. of mercury which allows arterial inflow but not venous out flow The dorsal veins will fill up fast or slowly depending on the rapidity of circulation through the extremity This modification eliminates the disturbing influence of insufficient venous valves in the presence of which the veins may fill rapidly through venous backflow This back pressure is eliminated through keeping the limb horizontal

Suction and pressure therapy has to be given in hospitals to hospitalized or ambulatory patients. A minimum of 100 hours is necessary to obtain any noticeable enlargement of the collateral vascular bed

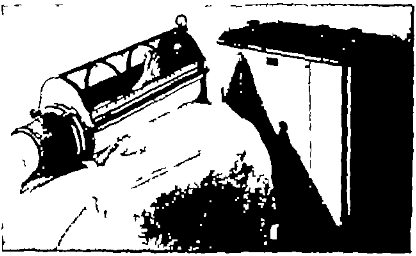

FIG. 3.—Suction and pressure machine for the treatment of peripheral vascular disease. The patient's leg is encased in an airtight, transparent boot and the environmental pressure around the limb is decreased and increased at varying cycles.

SUCTION AND PRESSURE THERAPY (Fig 3)

It is close to ten years now that two independent groups of workers described an apparatus designed to create an alternate negative and positive environment around a limb encased in an airtight box or boot.[13] From 1934 to 1940 four apparatus have been in continuous use in the two clinics under our observation and an evaluation of the obtained results revealed[14] that (1) the degree of improvement depended largely on the stage of the disease in which the treatment was started (2) that, with the exception of the Pavaex boot, all other apparatus created a mild venous stasis as determined by the oxygen saturation of the femoral venous blood before and after treatment (3) and that this stasis could be duplicated by a continuous compression with 40 mm of mercury for 40 minutes It was found by Veal and McCord[15] that if after one hour of treatment an increase in the oxygen saturation of the venous blood did not occur the treatment would not be effective and the prognosis was poor This would be the most logical method for selecting cases for treatment but it is not applicable for general clinical use because of the inconvenience of puncturing the femoral vein and the difficulty of getting reliable oxygen saturations from clinical laboratories. For this reason we decided to use ten treatments as a therapeutic test and if no subjective and objective improvement was noticed to discontinue the treatment.

In order to avoid treating patients in whom benefit cannot be obtained it seems helpful to group all patients suffering from obliterative vascular disease into four groups To the first group belong patients who can still walk five blocks without cramping and in whom the oscillometric index at the ankle is more than 0 5 cm. In this group both early and late results are good but unfortunately very few

therapy with some simple inexpensive method, which could be used in the home daily for a long period of time, a real service would be rendered especially to the ambulatory low wage earners or to the indigent population of the dispensaries These requirements are ful filled by intermittent venous hyperemia.

Intermittent Venous Hyperemia

In analyzing the mechanism by which alternating suction and pressure exert their effect on peripheral circulation de Takats Hick, and Coulter[18] found that an intermittent venous stasis occurred in the limb during treatment. The cuff of the boot encircling the thigh con stricts the limb during the phase of suction and releases it and empties the vessels during the phase of positive pressure. The phenomena of reddening of the toes filling of the veins which were interpreted as increase in circulation by the proponents of the method could be reproduced by alternate venous compression and release We thought, therefore that intermittent venous hyperemia might conceivably supplant the more elaborate method of suction and pressure.

Continuous venous stasis the so-called Bier's hyperemia has been used in cases of arteriosclerotic and juvenile gangrene but Thies in 1913 was first to point out that hours of continuous venous compression would lead to intractable indurations and advocated intermittent pressure and release.[19] He used venous compression for 60 seconds followed by a release from 90 to 120 seconds but used the method only for infections Collens and Wilensky[20] were the first to introduce alternate venous constriction and release in the treatment of peripheral vascular disease In congested ulcerated or gangrenous limbs the pressures never exceed 60 mm. of mercury in fact, they preferred to start with 40 mm When intermittent claudication was the outstanding symptom they applied pressures up to 90 mm. of mercury They constructed an efficient automatic apparatus which could be applied to both thighs simultaneously and adjusted to deliver different pressures with varying cycles.

We[18] employed a wide 8-inch leather cuff which the patient could alternately inflate and deflate by hand (Fig 4) An ordinary blood pressure apparatus could also be used. Later especially after the patients had had a few treatments at the hospital they were given a short strip of wide rubber bandage and taught to constrict and release the thigh During constriction a reddening of the toes and a filling of the dorsal veins had to be demonstrated

This was obviously a makeshift device but enabled a group of patients to receive treatment at home far from medical centers for little or no cost at all The method had obvious disadvantages in that in bilateral lesions one leg at a time had to be treated It required active participation of the patients which was not always possible They also got tired of it and finally it encouraged unsupervised treat ment in the home.

There are two conditions in which little can be expected from suction and pressure therapy When arteriolar disease is predominant, as pointed out by Louis G Herrmann,[17] tissue nutrition cannot be materially improved by enlarging the collateral bed. Arteriolar obstruction may be due to sclerosis, to endarteritis and to Buerger's disease In our experience Buerger's disease, even if it affects the major arteries, does not respond well to vascular exercises as long as the vasomotor nerves are intact. It seems as if both suction and pressure and intermittent venous hyperemia, to be discussed presently are capable of aggravating vasospasm when it is superimposed on organic vascular disease. For this reason, these mechanical exercises are far more efficient when they are combined with a permanent vasomotor paralysis such as is produced by sympathectomy or paravertebral alcohol block. In cases of elderly arteriosclerotics or in some cases of Buerger's disease when sympathetic block is not indicated or refused, a large abdominal heat cradle combined with mechanical therapy enhances the effect of the procedure by eliminating vasomotor tone

There are definite contraindications to the use of suction and pressure. In all forms of venous thrombosis this treatment is contraindicated. Thrombi may spread or become mobilized. Subacute and even chronic forms of phlebitis may be activated. Chronic postphlebitic edema may occasionally be benefited but the dangers of reactivating a chronic phlebitis are much greater than the benefit to be derived.

An acute spreading infection of the tissues with or without visible streaks of lymphangitis is an equally definite contraindication to alternate suction and pressure This treatment is essentially a form of gentle massage and is naturally inadvisable in cases of localized or spreading acute infection This does not mean that a chronic osteomyelitis of a toe or a chronic varicose ulcer could not be treated but in such cases a daily control for a possible spread of infection is advisable.

This treatment then is useful in the early, first and second stages of obliterative vascular disease it is useless in the more advanced forms When the patient has continuous pain at rest, when his toes are gangrenous and when there is beginning thrombosis in the plantar veins of the foot, the treatment often accelerates gangrene.

This form of therapy was a great advance in the treatment of chronic obliterative vascular disease, in the treatment of frostbites and in certain embolic occlusions But certain disadvantages became obvious The treatments were expensive. They could be given to patients many hours daily as long as they were hospitalized but when they became ambulatory one hour three times a week is the maximum period which the average patient could visit the hospital. The purchase or rental of such apparatus in the home was prohibitive for most patients. In free clinics and dispensaries the treatments tied up one or several nurses throughout the day

It seemed obvious that if one could substitute suction and pressure

enough to facilitate venous drainage. When the veins on the dorsum are empty a pressure of 60 to 80 mm of mercury is thrown into a blood pressure cuff placed around the thigh The time is noted when a good rubor of the toes and a thorough stretching of the dorsal veins occur *This is the optimal duration of compression the shorter this* period is the better the circulation. It may take although very sel dom three to four minutes to get a satisfactory rubor The pressure *applied must always be subdiastolic, but in cases with ulceration* venous stasis or edema the lower pressures as low as 30 to 40 mm. should be used. In most patients 60 mm. of pressure for two minutes gives a satisfactory response The duration of the release is equally important. When the cuff is deflated and the leg is slightly above the horizontal plane the rubor and venous filling disappear very quickly It would be tempting to employ a very short release such as 30 to 60 seconds in order to increase the number of constrictions during a course of treatment. But this is inadvisable. In the first place a cer tain amount of anoxia develops during constriction an oxygen debt develops which needs time to be repaid Collens and Wilensky[20] ex plained the beneficial effects of intermittent venous occlusion by the production of this reactive hyperemia, although this hyperemia is not *very evident with less than 80 mm of mercury We*[18] *tried to point* to the mechanical effect of filling and stretching of capillaries and venules during constriction. In this phase filtration pressure in the capillaries will be raised over the osmotic pressure of the blood The high intravascular tension of oxygen leads to increased saturation of the tissues which could be shown experimentally[21]

There has been considerable controversy regarding the value of intermittent venous occlusion. Allen and McKechnie[22] were unable to find a consistent rise in skin temperature following intermittent venous occlusion and hence they do not believe that significant vaso-dilatation follows its use It is improbable that a single treatment would produce much vasodilatation or permanent increase in blood flow The purpose of this therapy is as we have repeatedly empha sized to enlarge the capacity of the vascular bed especially the part of the bed which serves tissue nutrition Whether reactive hyperemia plays a part is controversial. Even if it is produced by arterial con-striction the subsequent hyperemia simply repays the oxygen debt accumulated during constriction.[23]

Just as in suction and pressure therapy the release of vasomotor tone greatly enhances the effect of intermittent venous hyperemia. Capps[24] found that even a pressure of 20 mm. of mercury would produce a great increase in limb volume when the sympathetic nerves were blocked For this reason heat cradles sympathetic block or *sympathectomy greatly enhances the effect of venous compression.* Thus the treatment can be combined with an abdominal heat cradle which is just as effective as short wave diathermy

In acute arterial occlusion treatments may be given for twelve

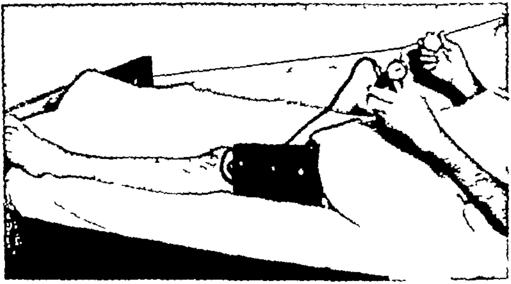

FIG. 4.—*Alternate venous constriction* and release produced by an 8-inch leather cuff. The patient's lower extremity is horizontal or slightly elevated on one pillow The patient alternately inflates and deflates the cuff at prescribed intervals. The patient is instructed to watch for filling of the veins of the foot and redness of the toes during constriction, which is a desirable reaction to be obtained.

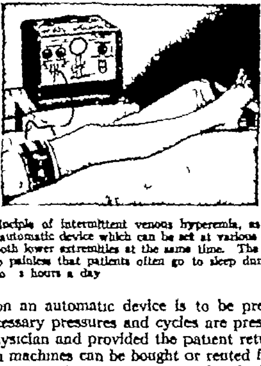

FIG. 5.—Same principle of intermittent venous hyperemia, as shown in Figure 4, is carried out by an automatic device which can be set at various pressures and various cycles and used on both lower extremities at the same time. The apparatus is noiseless and the procedure so painless that patients *often* go to sleep during treatment. They may use it f om to s hours a day

For this reason an automatic device is to be preferred (Fig 5) provided the necessary pressures and cycles are prescribed and readjusted by the physician and provided the patient returns for monthly inspections. Such machines can be bought or rented for comparatively small cost and have now been used in many hundred cases

The indications and contraindications are identical with those of suction and pressure therapy To arrive at the optimal pressures and cycles the patient s lower extremities are placed on one pillow just

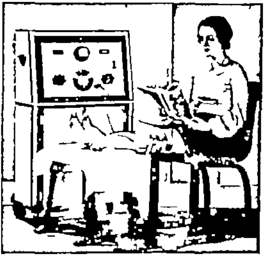

FIG. 6—Iontophoresis machine delivering a galvanic current with which mecholyl, sodium chloride or mercuric chloride can be carried into the tissues with the electric current. The patient should watch for sensation of warmth burning, as wheeling may occur if the current is too high

experience unless there is a large thrombophlebitic induration sur rounding the lesion It is the induration which requires softening and mecholyl iontophoresis has been of great benefit to a number of our patients although some of them will finally require surgical excision.

As stated by Wright,[29] mecholyl iontophoresis appears to be the most effective treatment thus far suggested for scleroderma. In over 70 cases studied about 70 per cent of them have shown definite improvement. Frequent treatments over prolonged periods of time have been necessary Our experience with true diffuse scleroderma has not been very satisfactory although temporary softening of the treated areas does occur Sclerodactylia occurring in connection with Raynaud s disease responds much better

Certain modifications have been made in our method of iontophoresis. In the first place a constricting cuff inflated to 40 mm of mercury has been maintained continuously during the treatment with either histamine or mecholyl (Fig 6) This prevents absorption from the area treated and abolishes the systemic reactions Secondly we substituted a 1 per cent solution of sodium chloride for the vasodilator using it on the positive pole The sodium ion entering the fibrotic tissue retains water and thus softens the tissues. The galvanic current itself has a vasodilator action which is absent in denervated skin.

Results with the sodium chloride iontophoresis which was mainly used to soften thrombophlebitic indurations have not been inferior to those obtained with mecholyl The cost of the solution is minimal and there are no side effects. The venous compression is still maintained because it helps to waterlog the tissues

Lastly some observations were made with a 1 1000 solution of

out of the twenty four hours. For severe chronic occlusion, four to six hours are prescribed. Patients at home usually take one hour three times a day Some prefer to take it during the night while sleeping. A minimum of three months of treatment is prescribed representing approximately 300 hours.

Our results have been better with intermittent venous hyperemia than with suction and pressure therapy simply because the patients can take treatments more often and for a longer period. Several patients have now used it for five years, taking the apparatus with them wherever they go One can readily satisfy oneself of the value of such treatment by discontinuing it for a month at a time. The venous filling time is the simplest objective measure of the improvement or deterioration of circulation

IONTOPHORESIS

The principles and technic of iontophoresis or common ion transfer have been extensively dealt with in Chapter 9 It was pointed out that the electric current not only breaks up the applied substance into its component ions but also produces electro-osmosis or the shifting of the water content through the pores of the skin The fact that vasodilator drugs could be administered by ionization made iontophoresis applicable to the treatment of peripheral vascular disease.

The discovery of Deutsch [25] that by iontophoresis with histamine marked flushing, whealing, urticaria and rise in temperature could be produced marked the start of numerous attempts to treat rheumatic traumatic and vascular diseases with histamine. First a 1 1000 histamine solution was used on the positive pole later a 1 per cent histamine ointment was rubbed into the skin which was previously scarified and then a 15 ma. current was passed through for three to five minutes Systemic reaction manifested in headache tachycardia, bronchial spasm and faintness were occasionally observed. We have used this method extensively in conjunction with the Department of Physical Therapy at Northwestern University but discontinued it because (1) the effect was fleeting (2) the side effects were frequent and (3) better drugs were found for iontophoresis Thus Kovacs [26] started the use of mecholyl the parasympathetic vasodilator by iontophoresis using 0 5 per cent solution of mecholyl on the positive pole.

The difficulty of treating peripheral vascular disorders by iontophoresis arose from the fact that while in fibrositis or arthritis a localized area had to be treated most vascular disorders are diffuse and it was difficult to see just what segment of the vascular tree needed treatment For this reason the usual forms of peripheral vascular disease such as obliterating arteriosclerosis Buerger's disease and Raynaud s disease were not treated in our clinic with iontophoresis The true field for iontophoresis lies in localized patches of scleroderma [27] and varicose ulcers.[28]

In varicose ulcers mecholyl iontophoresis is unnecessary in our

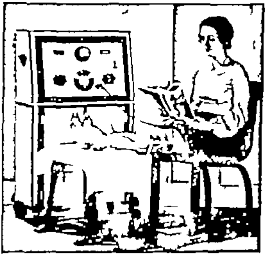

FIG. 6—Iontophoresis machine delivering a galvanic current with which mecholyl, sodium chloride or mercuric chloride can be carried into the tissues with the electric current. The patient should watch for a sensation of warmth o burning, as whealing may occur if th current is too high.

experience unless there is a large thrombophlebitic induration sur rounding the lesion It is the induration which requires softening and mecholyl iontophoresis has been of great benefit to a number of our patients although some of them will finally require surgical excision.

As stated by Wright[29] mecholyl iontophoresis appears to be the most effective treatment thus far suggested for scleroderma. In over 70 cases studied about 70 per cent of them have shown definite improvement. Frequent treatments over prolonged periods of time have been necessary Our experience with true diffuse scleroderma has not been very satisfactory although temporary softening of the treated areas does occur Sclerodactylia occurring in connection with Raynaud s disease responds much better

Certain modifications have been made in our method of iontophoresis. In the first place a constricting cuff inflated to 40 mm of mercury has been maintained continuously during the treatment with either histamine or mecholyl (Fig 6) This prevents absorption from the area treated and abolishes the systemic reactions Secondly we substituted a 1 per cent solution of sodium chloride for the vasodilator using it on the positive pole The sodium ion entering the fibrotic tissue retains water and thus softens the tissues. The galvanic current itself has a vasodilator action which is absent in denervated skin

Results with the sodium chloride iontophoresis which was mainly used to soften thrombophlebitic indurations have not been inferior to those obtained with mecholyl The cost of the solution is minimal and there are no side effects The venous compression is still maintained because it helps to waterlog the tissues

Lastly some observations were made with a 1 1000 solution of

mercury bichloride introduced through the positive pole The effect of the mercury ion on chronic granulations even if nonsyphilitic is well known. One of the most baffling problems in the treatment of chronic vascular disorders namely, the large thrombophlebitic indura tions seems to respond favorably to biweekly treatments for prolonged periods Such indurations contain areas of fat necrosis, lymphocytic infiltrations, and thickened lymph channels, they required radical excisions in the past. Iontophoresis with mercury and con tinuous elastic support seem to give promise of a simple ambulatory treatment The skin may become sensitized to mercury

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